1999

An Executive Guide to Space: A Starting Point for Understanding Space in the New Millennium

Lt Col Steven D Carey

20000428 060

P-8041-1

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Published 2000 by RAND
1700 Main Street, P.O. Box 2138, Santa Monica, CA 90407-2138
1333 H St., N.W., Washington, D.C. 20005-4707

PREFACE

Understanding space and how America plans to use it in the new millennium has captured the attention of our national leadership. Each branch of service within the military has discovered the tremendous warfighting potential of space. Such realization has fired intense doctrinal debates as well as fiscal competition for dwindling resources under the umbrella of this new frontier. These emerging debates and the bottom-line budget battles have brought an entirely new dimension to our national priorities, which until now have been based on three mediums of warfare—land, sea, and air. Space brings us into the fourth dimension of warfare. As we move our warfighting into this new medium, it is imperative that we develop a fundamental appreciation and understanding of the "nuts and bolts" of our current space debate.

As a matter of natural evolution, the United States Air Force has become our nation's space arbitrator and now plays a vital role in shaping our national priorities and strategic vision. Our leadership will be the first to admit that our direction is evolving. As a nation, we are breaking new ground and there is no doubt that space will dominate our nation's ability to project political, economic, and military power around the globe. We cannot miss the opportunity to fully debate the issues that face us as a nation.

These debates are boiling inside the beltway and have shifted the priorities on many political and corporate agendas. Today, this tempest debate churns at the forefront of our senior military and political agendas. Ironically, this debate lacks serious participation from those most aptly suited to import bold ideas and dramatically influence space policy--our middle leadership and decision makers, both military and civilian. This middle leadership cluster has been following the debate from the sidelines. With passive head nods of pseudo understanding, our middle leadership views the space debate from the sidelines, does not understand the fundamentals that impact the strategic decisions surrounding space and consequently, is not directly involved in shaping the decision process.

Rather, the middle ranks of military officers, government officials and corporate America simply head nod when they read a New York Times editorial on space power or an in-depth analysis of our space road map. This middle

leadership "head nod" is due in part to a peripheral understanding of the issues that surround the national space debate. During my research, I quickly played myself as one of those head nodders and realized I was not prepared to jump headlong into the current debate. Much like a Little Leaguer, I recognized you couldn't bypass spring training and expect to play in the majors.

Most of our middle leadership find themselves keenly interested in space issues but unschooled in the fundamentals that shape it. That is an unhealthy predicament; we need to level the field and build a common starting point. How many times have you found yourself scratching your head trying to understand terms like orbit inclination, or the economics of space commercialization or why we need to define national space boundaries? In my view, these and other questions deserve out attention before we can move forward and address some of the more complex issues affecting our national space policy.

This Executive Guide is a simple starting point and takes a few steps back for those who have not been schooled in space. Hopefully, it will fill in some fundamental gaps for those readers who are not familiar with space jargon and have not spent a career in the space business. To reduce the discussion and simplify magnitude of space issues, the guide addresses several core areas. Section 8, Military Prognosis, possesses a series of questions for those who wonder what space holds for the military. Keep in mind, this guide is not a space encyclopedia but rather an introduction to the fundamental concepts that underlay our national space debate. Written by a fighter pilot who watched Star Trek and admired the leadership of Captain Kirk, this Executive Guide will not show you how to build the Enterprise but it will arm you with the "nuts and bolts" currently shaping our national space priorities.

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Project AIR FORCE

Project AIR FORCE, a division of RAND, is the Air Force federally funded research and development center (FFRDC) for studies and analysis. It provides the Air Force with independent analyses of policy alternatives affecting the development, employment, combat readiness, and support of current and future aerospace forces. Research is performed in four programs: Aerospace Force Development; Manpower, Personnel, and Training; Resource Management; and Strategy and Doctrine.

ABOUT THE AUTHOR

Lieutenant Colonel Steven D. Carey brings to RAND a wide range of unique operational and staff experience. A combat seasoned fighter pilot with almost 4000 flying hours, Lt. Col. Carey recently commanded a 24 aircraft F-15C air superiority squadron consisting of 30 officers and over 350 enlisted personnel. As Commander of the 58th Fighter Squadron, he led the air superiority element of the Air Force's first ever no-notice real world Air Expeditionary Force deployment to Southwest Asia. Coupled with his air-to-air background, Steve has over 1400 hours in the multi-role F-16C flying with the Pacific Air Forces and Tactical Air Command. As an F-16C Instructor Pilot and Mission Commander, Steve also served as the 9th Air Force F-16 Aerial Demonstration Pilot flying over 100 airshows throughout North America and in 1988, was selected as Tactical Air Command's Flight Commander of the Year. His broad operational experience also includes a tour as a speechwriter and key briefer for the Commander of Air Combat Command. Although the majority of his operational flying is in fighters, Lt. Col. Carey flew combat missions as a Weapons Allocation Officer on JSTARS during Desert Storm. Lieutenant Colonel Carey was commissioned through the United States Air Force Academy and holds a degree in history as well as masters in business. He is a graduate of Squadron Officer School, Air Command and Staff and Air War College.
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1. BRIEF HISTORY OF SPACE

Space has always captured the curiosity of man. From the early stargazers who pondered the mere idea of flight to modern era engineers who see Star Wars as an eventual reality (without some of the characters), space and man's ability to use it have tweaked our imagination. Historically, early space exploration was simply buried in the pages of science fiction or on the notepads of philosophers and inventors. It wasn't until the beginning of the 20th century that those farfetched ideas and musings began to move from drawing pad to the laboratory and eventually the skies. This section will walk through the highlights of our space journey and provide an insight as to how far we have traveled this century.

THE WAR YEARS AND ROCKET RESEARCH

Jules Verne and Orson Wells helped shape our imagination and inspire many exciting images, but the real impetus for space development came from the national efforts exerted by Dr Wernher Von Braun under the cloak of German secrecy prior to World War II. While America's interest was haphazard and lacked any concerted financial support, European rocketeers took an early lead in the pursuit of rocket science. (Muolo 1993a, p1) Germany's aggressive research program and early successes piqued the attention of the allies and their intelligence communities. Germany's large-scale research and development centers became the golden egg for the Allies. Most notably, the United States and Russia charted plans to acquire these facilities and the scientific treasures within their walls.

Back on the home front, American scientist, Robert Goddard, single-handedly promoted and sustained the American space banner while the nation watched Europe prepare for World War II. Recognized as one of America's greatest rocket scientists, Goddard kept us "in the hunt" ensuring rocketry and the development of space remained close to the forefront of our national scientific priority. Goddard's impact is remarkable and his list of accomplishments included many firsts--the first functional gyroscopic altitude control system for rockets, the first liquid propellant rocket, and the first pressure pump feed systems. (Muolo 1993a, p1)

As World War II consumed the globe, the potential of space and the leverage it offered the military, created a frenzy within the Third Reich as well as the Allied powers. Germany's sophisticated research and testing facilities made the Allies extremely nervous and concerned about the German technological edge. (Muolo 1993a, p1) When the V-2s began to rain terror on the populations of England, many acknowledged the tactical impact as insignificant but hailed the strategic potential. These vengeance-and-terror weapons as they were labeled, represented a tremendous scientific achievement and were considered the first medium-range ballistic missile. Vengeful or not, this technology kickstarted the space race. The Allied rush to capture the technology was on. As the final chapter of World War II came to a close, the Americans found themselves sprinting on the battlefield to secure Germany's scientific spoils first, and more importantly, to deny the sharing of such valued information with the Russians.

The National Advisory Committee for Aeronautics (NACA) was founded in 1915 and was the precursor to the National Aeronautics and Space Administration (NASA). While Dr Goddard was clearly recognized as the man in the pulpit of space development at this time, NACA was our organizational attempt at harnessing space and aeronautics during this era.

As the Third Reich unleashed the V-2s on England, members of the U.S. scientific community under the umbrella of NACA helped focus our military attention on the potential of Germany's rocketry and propulsion advances. Consequently, the United States decided to extract rocket experience from Russian occupation zones under the cover of Operation Hermes. This military effort culminated with the surrender of the famed Peenemunde Rocket Group (PRG) in the spring of 1945. (Muolo 1993a, p2) Along with PRG's surrender came the scientific genius behind the scenes, Wernher Von Braun, known as the Father of Modern Rocketry. Over the next years, Dr Von Braun helped the United States influence the subtle defection and subsequent hiring of hundreds of German scientists and technicians.

COLD WAR BEGINNINGS AND THE ENSUING SPACE RACE

With the scientific spoils of World War II divided between the United States and Soviet Union, the foundation for an east-west rivalry filled with suspicions was set. During the early stages of the Cold War, our national

research included initiatives to develop a 5,000-mile inter-continental ballistic missile as well as heavy rocket launchers. However, by 1947, these programs lost national support because many senior leaders were skeptical about the viability of mating nuclear weapons on long-range missiles. (Muolo 1993a, p3) Not until a major technological breakthrough in 1948, did the option of long-range missiles become a reality. Transistors, invented in Bell Telephone Labs, were smaller and lighter than the heavy tube technology, which dominated space research, and the development of transistors reenergized the space race. (Muolo 1993a, p3)

The technology race during the Cold War had a dramatic impact on domestic politics. The Hydrogen bombs tested by both the U.S. and the Soviet Union in the early 1950s marked a significant space milestone and completely changed the outlook and future of ballistic warfare. Now, missiles could carry the more destructive H-bomb instead of the cumbersome A-bomb. Furthermore, satellites were now being considered as national platforms to view adversary nations. The space race engendered many fears among Americans and our leaders began to wrestle with the consequences of these technologies. In 1954, President Eisenhower introduced the Open Skies theory to the international community hoping to reduce the risk of a "nuclear Pearl Harbor" by proposing the United States and USSR exchange critical information, and more importantly, permit overflight of each country for verification. Although hailed by the international community, the suspicious Soviets rejected the proposal. (Muolo 1993a, p4)

With the Cold War in full swing, U.S. space initiatives in the 1950s could be characterized as very reactive. Both the Soviets and U.S. put national prestige on the line and proposed launching a satellite during the decade's big scientific extravaganza called the International Geophysical Year in 1957. Early on, analysts in the U.S. were not fearful of Soviet missile capability and felt confident that the U.S. space program owned a comfortable lead. However, this confidence was shattered in 1957 when the Soviets declared they had developed the first successful Intercontinental Ballistic Missile (ICBM) and quickly followed that announcement with the stunning launch of the world's first satellite, Sputnik. (Muolo 1993a, p6) Compounded by miserable failure of the Vanguard Program which brought images of U.S. satellites blowing up on the launch pad, it was clear the U.S. space program lacked national direction and focus. The

American public recognized that the Soviets owned a prestigious lead in the space race.

THE SPACE ACT OF 1958 AND THE RACE TO LAND MAN ON THE MOON

The fallout of these events was a watershed for the United States space program. Congress quickly enacted the National Aeronautics and Space Act of 1958 which created the National Aeronautics and Space Administration and solidified space policy by absorbing various space related agencies. (Muolo 1993a, p8) Now NASA had the attention of Congress and the American public. With a generic agenda, NASA was designed as a civilian organization intended for the peaceful development of space. This loose framework would shape our national space policies and create an evolving relationship with the Department of Defense for the next forty years.

As we stepped into the sixties, NASA and the DOD were faced with a bold and dangerous new world arena. ICBMs were a reality and brought the devastating consequence of nuclear war to our doorsteps. Satellites apparently offered solutions to many age-old problems of reconnaissance, communication, and navigation. Militaries and governments alike recognized the dynamics of these technologies and sought to develop and capitalize on these critical space capabilities. From their perspective, these capabilities could ensure national security as well as garner international prestige and enhance economic progress.

Although NASA represented an institutional consolidation of our space effort under the civilian sector, the military lacked any clear guidance and played second fiddle to NASA's quest to put man on the moon. Throughout much of the 1960s, the military space effort was cloaked in secrecy under such "black" programs as Corona. With all of NASA's space fanfare, the public was generally uninformed about the military's role in the U.S. space program. Operating in the shadows of NASA's robust space effort, the military's "black" programs and priorities never received the public's attention. However, under the Kennedy administration, some organizational initiatives remedied this problem. Defense Secretary McNamara made the Air Force the lead military agency for space, giving it responsibility for all research and development, operations of DOD satellites, and all ground support. (Muolo 1993a, p16) From this directive, the Air Force role has evolved over the decades to its

present architecture under the Unified Combatant Command, United States Space Command (USSPACECOM). The specifics of this command are addressed in Section 4. However, it is important to keep in mind that Secretary McNamara's 1961 DOD Directive still holds true and the Air Force remains caretaker and steward for most DOD space programs.

The sixties were shaped by President Kennedy's promise to land a manned spacecraft on the moon at the end of the decade, and his decision to mask the activities of our military space program. (Muolo 1993a, p16) NASA had a clear-cut agenda and many national resources were poured into the effort to reach the moon. On the other hand, the military chose to operate their arm of the space race cloaked in secrecy. The military's veil of secrecy created a problem for NASA who relied almost solely on DOD for any launch capability; this included providing launch personnel, launch facilities, as well as launch vehicles.

Although the United States lost the effort to put man in space first when the Soviets launched Vostok 1 with Yuri Gagarin in 1961, it was more an issue of perception than capability. Only months before Gagarin's historic flight, the U.S. had successfully launched and recovered a chimpanzee. Some might say it was merely timing and that the assessments of risk versus safety separated the two national space programs. No matter, the Soviets claimed the prestigious high ground as the first nation to put man in space. With Alan Shephard's American debut in a Mercury spaceship only a few months later, the world recognized that both space programs were in a photo finish. However, this deadlock was not long lasting as NASA stepped into high gear and adopted Kennedy's mantra to put man on the moon by the end of the decade.

With Project Mercury and follow-on program Gemini, NASA was building a program aimed at achieving a moonwalk within the decade, and more importantly, before the Soviets. Congress had opened up the coffers and NASA harnessed the intellect and resources of a nation. However, NASA quickly developed a distinct agenda, which paralleled and in some cases, conflicted with the military's launch priorities. NASA's aforementioned dependence on the military for launch capability set the services in conflict with NASA's imperative to put man on the moon. Consequently, as the NASA effort mushroomed in scope and complexity, the Air Force's ability to shape and influence space policy and launch decisions diminished. This conflict

highlighted the competing divergence of our military and civilian space programs and would eventually manifest itself in a prophetic decision to develop the space shuttle as the nation's primary means of sending man and equipment into space.

NASA celebrated a decade of national resolve with the successful Apollo 11 mission when Neil Armstrong set foot on the moon and reversed the imbalance established by Sputnik and Yuri Gagarin. Without a doubt, this was a high point for the U.S. space program. Although NASA would still enjoy a groundswell of enthusiasm and national support, the underlying national resolve and commitment for manned space exploration began to erode. Prior to the famed Apollo mission, the DOD had endured a series of severe cutbacks and program cancellations, which only served as a foreshadowing for NASA's upcoming fiscal battles.

THE U.S. SPACE PROGRAM MATURES AND NATIONAL VISION TAKES SHAPE

During the seventies, the momentum of the U.S. space program shifted from NASA to the military. Most Americans were satisfied that the U.S. had reclaimed the prestigious high ground with Armstrong's ridged footprint on the moon and no longer were obsessed with space and its budget demands. Ironically, as domestic enthusiasm quelled, many of our leaders found little comfort in the assessment that the Soviets had an anti-satellite capability (ASAT). This assessment revitalized the U.S. interest in ASAT and satellite survivability. Additionally, President Carter's 1978 Presidential Decision dramatically altered U.S. space policy. In short, the success of NASA's Apollo program was quickly overshadowed by the consequence of ASAT technology and the U.S. decision to regard space as a warfighting medium.

The eighties were prophetic in terms of U.S. space policy decisions. In 1981, President Reagan called for a more "permanent presence in space" and then issued the National Security Decision Directive-42 (NSDD-42) which bolstered the U.S. ASAT effort to protect national interests and designated the Space Shuttle as the primary space vehicle. (Muolo 1993a, p40,44) No doubt, these announcements laid the groundwork for President Reagan's historic Strategic Defense Initiative (SDI), which he introduced with great fanfare in 1983. President Reagan's SDI program sent shockwaves through the Soviet space program because it signaled the U.S. was willing to escalate the technology

race in order to design, develop, and place into operation a system that would provide strategic defense against ICBMs. Arguing that ASAT treaties with the Soviets were not verifiable and hence, poor national policy, President Reagan chose to build a shield, which would counter any Soviet attack. This SDI pronouncement became the framework of our military space research and development efforts and garnered large portions of the DOD budgets.

The other interesting aspect of NSDD-42 was that NASA and DOD were directed to develop the Space Shuttle as the primary means of accessing space. Although DOD had spent decades developing and successfully using expendable launch vehicles (ELV), the Space Shuttle now represented an all or nothing opportunity. In short, the U.S. space program was shifting from the traditional means of ELV under the military to the more efficient Space Shuttle or Reusable Launch Vehicle (RLV) under NASA. From an investment perspective, this decision made economic sense until the Challenger disaster in 1986.

Since the ELV capability was being phased out, the Challenger explosion and the subsequent grounding of the shuttle fleet was a death knell for the U.S. space program. The world had come to rely on the Shuttle to launch its commercial payloads and DOD had grudgingly reduced its alternative ELV pipeline. With rising commercial and military demands, everyone was scrambling to get their payloads into space. Consequently, NASA and the U.S. lost their dominant share of the worldwide launch market. Since the Challenger disaster, worldwide economic competition for launches has leveled space access opportunities and for the DOD, ELVs have reclaimed their role as the primary means for launching military payloads.

The Challenger accident cost the U.S. market dominance in launch capability but it awakened our leadership to a growing global dependence on space and highlighted the strategic importance of ensuring free access. Under President Bush, the National Space Council came into being and recognized "space is of vital importance to the nation's future and the quality of life on earth." (Muolo 1993a, p45) With the nineties, the world recognized how space was rapidly becoming a critical mainstay to the quality and functionality of our day-to-day lives. Real time global news broadcasts, communications access, precise global positioning, weather reporting, and remote sensing were influencing how we lived and worked. Desert Storm demonstrated how space

affects the character of war--how it is fought, viewed, and understood by the world. This decade was a catharsis. Commercial and military developments within the space industry took root in the mainstream of our global existence. As we move into the new millennium, space offers the world unimaginable economic benefits and potentially dramatic changes in the conduct of warfare. Space, our access to it and use of it, holds the future captive. The commercial character of space and its growing influence during this decade are discussed in Section 6.

2. ORBIT FUNDAMENTALS

Space has dominated scientific jargon for centuries. During which time, mathematicians and scientists have filled their notebooks with brilliant and not so brilliant ideas and postulations. Some have taken root and others remain to be proven. However, since the beginning of man's attempt at quantifying space and its principles, two individuals and their ideas have emerged as the theoretical bedrock of modern man's technical success at breaking the confines of gravity and stepping into the new dimension of space. The postulations of Germany's Johannes Kepler and England's Sir Isaac Newton provided the architecture for celestial travel. Our celestial exploration is founded in what many call orbit fundamentals.

Understanding the language and the ideas that enable man to launch satellites, maintain orbits, travel to planets, and take advantage of the benefits space offers should not be limited to those with SAT scores over 1700. Historically, space and its impact on our lives has moved from the laboratory to our backyard. It is no longer appropriate to shrug off terms like escape velocity, orbit inclination, and geosynchronous. Orbital schooling is a perquisite for all of us--warrior, businessman, and politician. Addressing the Laws of Kepler and Newton is not intended to punish you for nodding off during high school geometry or skipping freshman physics. Rather, these laws are the technical bedrock of our current and future space mission. So, call it a review or call it punishment, this section introduces the fundamental theories and terms used within the space community.

KEPLER AND NEWTON INSPIRE THE SPACE RENAISSANCE

Fueling the space renaissance and expanding Copernicus's idea that the sun was the center of the solar system, German scientist Johannes Kepler devised three laws of planetary motion: the planets move along ellipses with the sun at one focus, the orbits of the planets cover equal areas in equal times, and finally, the square of the orbit period is proportional to the cube of the distance to the sun. Ouch! Now, since a picture is worth a

thousand words, those laws are more easily understood with the diagrams below. (Sellers 1996, p16-17)

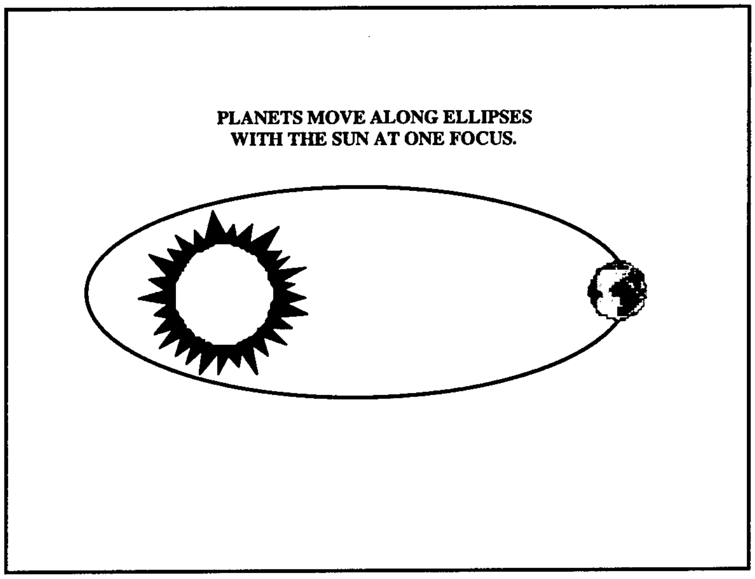


Figure 1—Kepler's 1st Law

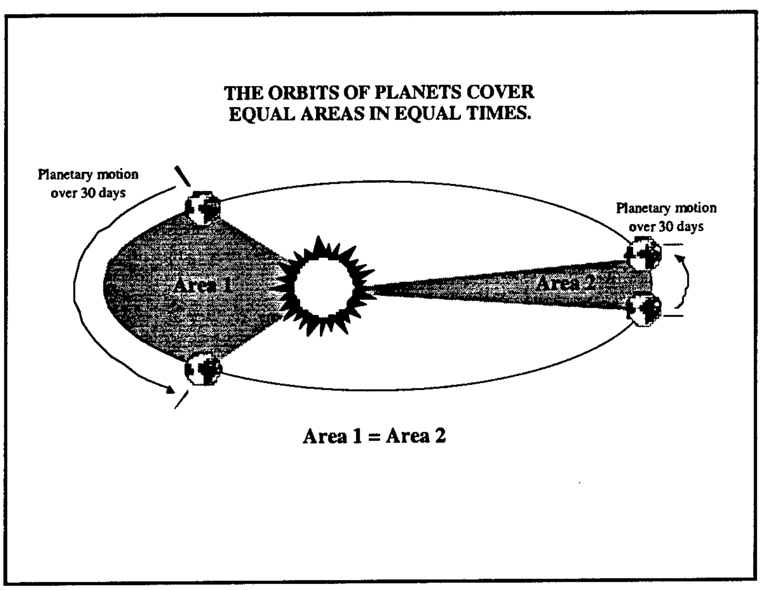


Figure 2—Kepler's 2nd Law

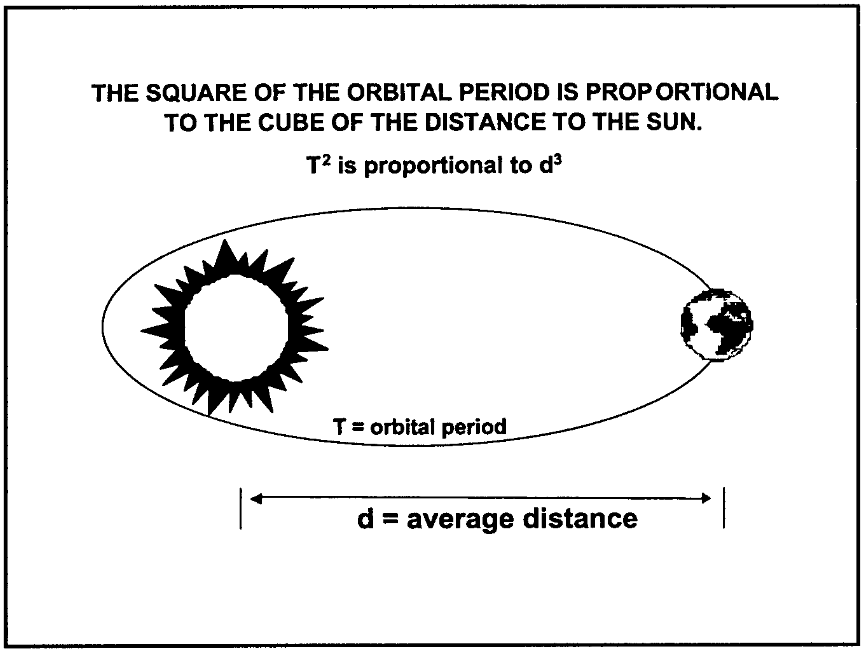


Figure 3—Kepler's 3rd Law

Expanding on the scientific enlightenment of this era, Sir Isacc Newton completed the astronomical revolution by framing the natural laws of motion for terrestrial and heavenly motion when he published Principia in 1687. (Sellers 1996, p18) Hailed as the answer to predicting the consequences of motion, Newton's Laws included: a body remains at rest or in constant motion until it is acted upon by another force, force is proportional to an object's rate of acceleration or deceleration, and for every force, there is an equal force in the opposite direction. These laws have provided an explanation for many natural and man-made motion related events and have enabled man to predict the outcome of mass, motion, and velocity. Along with those three laws, Newton also published the Law of Universal Gravitation, which simplistically states that an object's mass and its distance from another object influence the gravitational force it can generate.

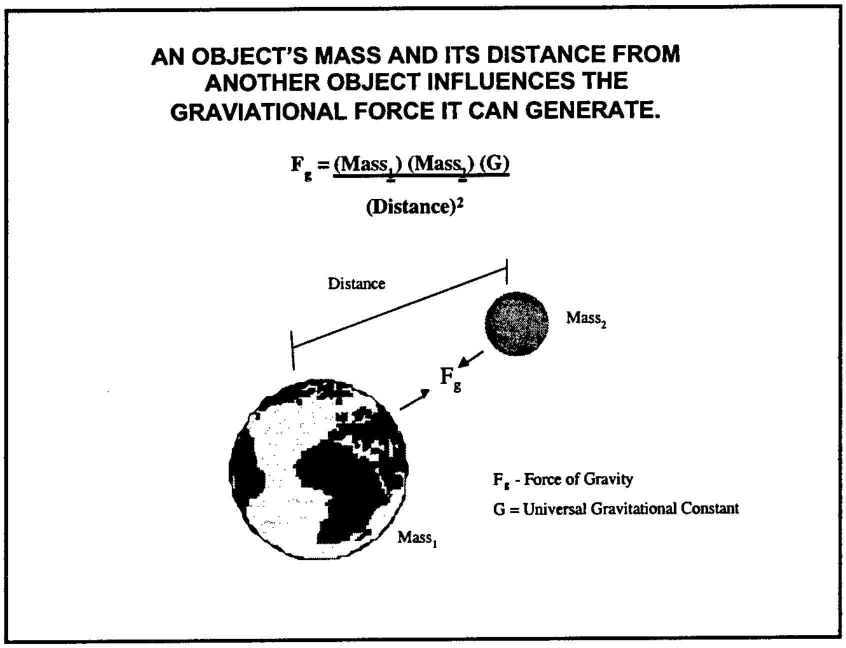


Figure 4—Newton's Law of Universal Gravitation

Your collegiate review is complete and hopefully, Kepler's and Newton's Laws aren't something for you to grimace about. Now you are armed with the scientific fundamentals of the space mission. The why's and how's of satellite launches and orbit maintenance will not seem so foreign. Remember, simple laws govern the motion of jet fighters and airliners as well as space vehicles. The space orbits of today's modern satellites obey the same simple laws as defined by Kepler and Newton.

With theory tucked away, it's time to address the practical side of the space mission. The remainder of this section is structured with these simple questions:

- What defines the vertical dimensions of space?
- What determines an orbit?
- What are the various types of orbits?
- What missions are best suited for each orbit?

WHAT DEFINES THE VERTICAL DIMENSIONS OF SPACE?

Many arguments muddy the definition of space and where it actually begins for us earthlings. Near-space is fairly comprehensive and includes everything in the solar system from earth to the sun comprising about 93 million miles of space and a few inner planets. However, the technical definition of real

space is not quite as easily packaged. Functionally, the scientific community has drawn several lines in the sand and generally speaking, each line of demarcation seems to make sense. The arguments and ensuing definitions stem from a functional orientation. Physiologists draw the line where man looses his independent ability to sustain life, while propulsion engineers mark the point where ramjet engines cannot provide thrust, whereas aeronautical engineers claim the disappearance of typical drag and lift forces as the criteria. In any event, international law, amidst decades of tested treaties and national proclamations, has failed to establish a boundary between airspace and outer space. Nevertheless, a proposal to set the boundary as the lowest orbit attained by orbiting space vehicles seems to be gaining support.

As often seems to be the case, legal definitions are not always very tangible and do not offer a practical explanation. So, in an attempt to add perspective and build a picture of the space medium, Table 1 offers a quantifiable perspective of the accepted vertical limits of space.

Table 1

Vertical Definitions of Space

Miles	Vertical Limits of Space
2	AF requires members to use supplemental oxygen
3	Half the earth's atmosphere is below this altitude
9	Pressure cabins and suits become a necessity
12	Gas bubbles appear in mucous membranes
15	Man cannot exist without a sealed environment
20	Turbojet engines cannot operate
28	Ramjet engines cannot operate
62	Aerodynamic lift and drag forces almost nonexistent
93	Lowest earth orbit (LEO)/accepted boundary of space
100	Region of darkness and utter silence
930	Medium earth orbit (MEO)
22,250	High earth orbit and geosynchronous orbit (GEO)

Source: (Muolo 1993b, p4)

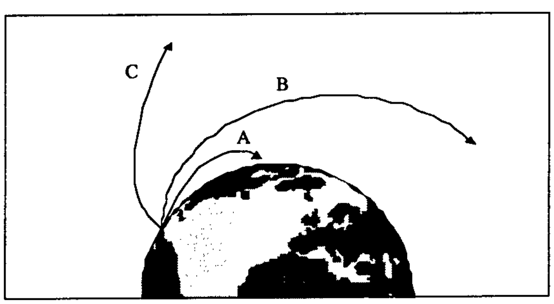
WHAT DETERMINES AN ORBIT?

A general discussion of orbits must include the key elements of size, shape, orientation, and altitude. In order to reach an orbit, a launch vehicle (LV) must achieve a velocity between 17,000-25,000 mph. Anything less than 17,000 mph will cause the vehicle to fall back to earth; hence 17,000 mph is called a fall-back velocity. To enter a low earth orbit, an LV needs a

velocity of about 8km/sec (i.e., 17,000 mph). On the other hand, anything in excess of 25,000 mph or 11.2 km/sec will slingshot the LV outside the earth's gravitational pull; hence, 25,000 mph is called escape velocity. In simple terms, a launch vehicle must achieve a velocity that can overcome the effects of atmospheric drag as well as the Earth's gravity. In the case of medium and high altitude orbits, once a LV achieves orbit, atmospheric drag is no longer a factor. However, satellites in low earth orbits are effected by atmospheric drag and as such, require velocity adjustments to maintain orbit. The following equation is an oversimplification but helps illustrate the dynamics of an orbit.

$$\text{Velocity} - (\text{Drag} + \text{Gravity}) = \text{Orbit}$$

In short, the countering forces of gravity and drag can result in three different paths. As shown in Figure 5, Path A is a suborbital in which the satellite falls back to earth, Path B is a closed loop or orbit profile where gravity and launch velocity are equal, and Path C is an escape profile where launch velocity exceeds the Earth's gravitational pull. (Collins 1989, p12)



Path A. Suborbital; vehicle velocity to slow to overcome gravity.
Path B. Earth orbit; vehicle velocity and gravity equal
Path C. Escape; vehicle velocity overcomes gravity pull.

Figure 5—Launch Velocity Profiles

The size of a satellite's orbit determines the orbital period and is directly related to its launch velocity. Generally, the LV drives the

satellite into an elliptical orbit with the earth as the primary focus of the ellipse. As shown in Figure 6, the orbit path has a close point or perigee and a distant point or apogee, both of which depend on the velocity of the satellite.

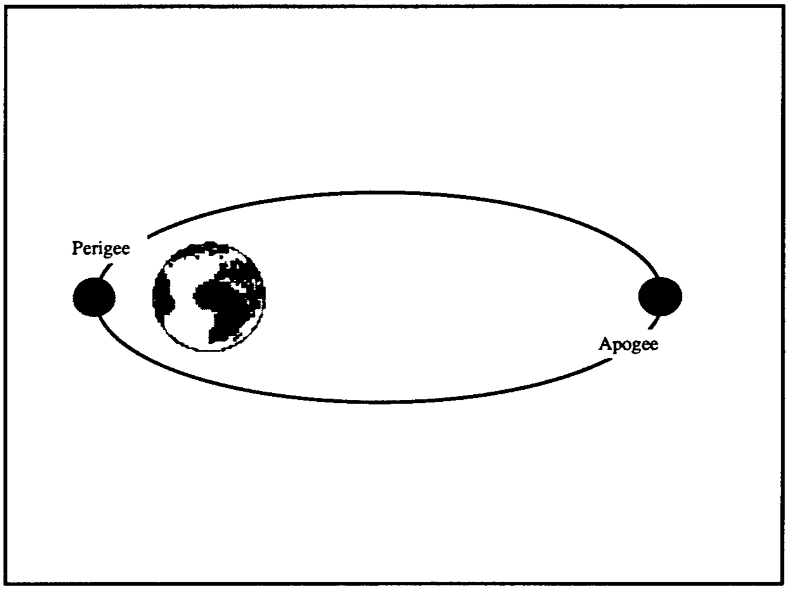


Figure 6—Elliptical Orbit - Apogee and Perigee

The shape of an orbit can vary and is measured with respect to a perfectly circular orbit. In practice, purely circular orbits cannot be achieved. Typically, an orbit is stretched or elongated and its proximity to the Earth's surface varies due to a variety of factors such as the Earth's bulge, sunspots, and atmospheric friction. As the satellite's orbit flattens out or elongates its eccentricity (e) increases. Eccentricity is measured as a factor between 0 and 1. A perfectly circular orbit has an eccentricity of zero. As an orbit elongates and becomes more elliptical, its eccentricity approaches 1.

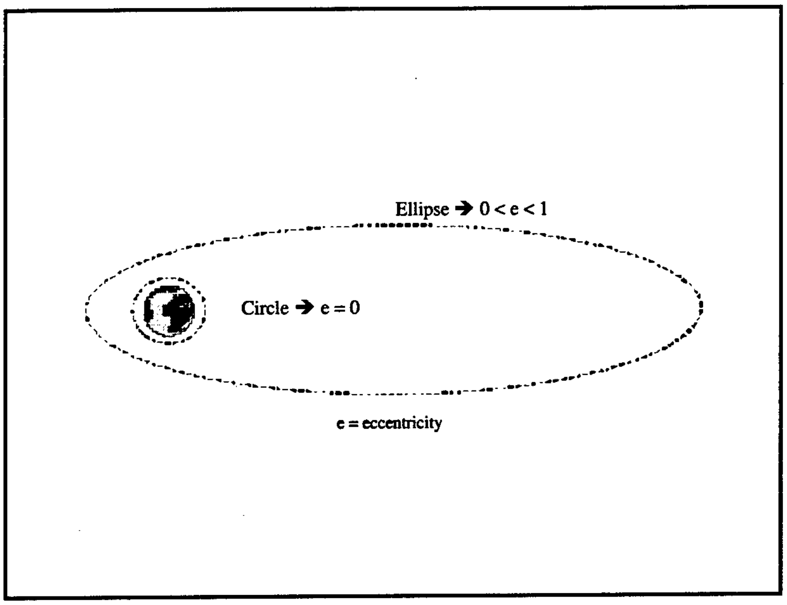


Figure 7—Orbit Eccentricity

Orbit size and shape depend on launch velocity whereas orbit orientation is determined by the satellite's path across the Earth's surface. More specifically, inclination is measured as the angle that a satellite crosses the equator along its orbit path. Orbit inclination can range from 0 to 180 degrees. Orbits at 90 degrees go right over the poles; orbits greater than 90 degrees are launched opposite the Earth's rotation and are called "retrograde." On the other hand, equatorial orbits have 0-degree inclination and follow a ground track directly overhead the equator.

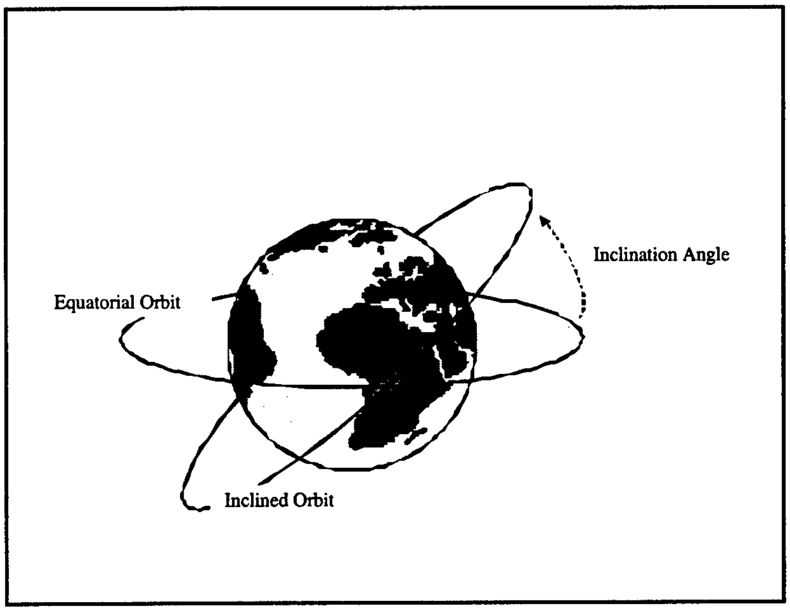


Figure 8—Orbit Inclination

Orbits vary in altitude above the earth and can be separated into these three categories: low, medium, and high. Low earth orbits (LEO) range from 150-1500km (93-930 miles) and comprise a large number of today's operational satellites. Although drag is a significant problem and LEOs require periodic boosts to maintain orbit, they are ideal for observation sensors. On the other hand, medium earth orbits (MEO) range from 1500-35,800km (930-22,250 miles) and are limited to unmanned satellites due to the serious effects of space radiation. MEOs include semi-synchronous orbits that are ideally suited for navigation and communication with 12-hour orbits that follow identical ground tracks. Above 35,800km (22,250 miles), is a region of high earth orbits which includes geosynchronous (GEO), geostationary (GSO) or Molniya. At a precise altitude of 35,800km, geosynchronous satellites track on or near the equator and maintain nearly 0-degree inclination. On the other hand, geostationary orbits are also positioned at 35,800km but actually orbit with 0-degree inclination. In order to maintain this perfect inclination, these stationary orbits require constant adjustments with fuel burns to remain "on spot." The Molniya orbit is a highly elliptical orbit (HEO) that offers some unique viewing advantages. In any event, all of these orbits are ideal for viewing large expanses of the Earth's surface and are superb for communication and surveillance platforms.

Table 2

Orbits - Altitude, Attitude, and Period

Orbits	Altitude (km)	Attitude (miles)	Period
Low earth orbit (LEO)	150-1500	93-930	1.5 hours
Medium altitude orbit (MEO)	1500-35,800	930-22,250	2-24 hours
High altitude orbit	At or above 35,800	22,250	24 hours

LEOs have a tremendous advantage for optical sensing but have a small field of view and can be significantly effected by atmospheric drag. Upwards of 80% of our current inventory of satellites are orbiting in this region. On the other hand, medium altitude orbits do not hold any particular advantage. The high amounts of radiation from the Van Allen Radiation Belt makes this region unhabitable by manned spacecraft and also plays havoc with unmanned electrical systems. (Space Basics, p118) As such, this region is sparsely populated with the exception of semi-synchronous satellites, which have a period of 12 hours and are ideally suited for specific communication and navigation systems. (Space Basics, p118) As mentioned, high altitude orbits include geosynchronous, geostationary, and Molniya orbits, all of which offer tremendous area coverage. In today's global marketplace, many nations desire the characteristics of geostationary orbits since they are so well suited for both communication and navigation platforms.

WHAT ARE THE VARIOUS TYPES OF ORBITS?

There are three general categories of orbits: geosynchronous, polar, and inclined orbits. Each orbit profile is depicted in Figure 9.

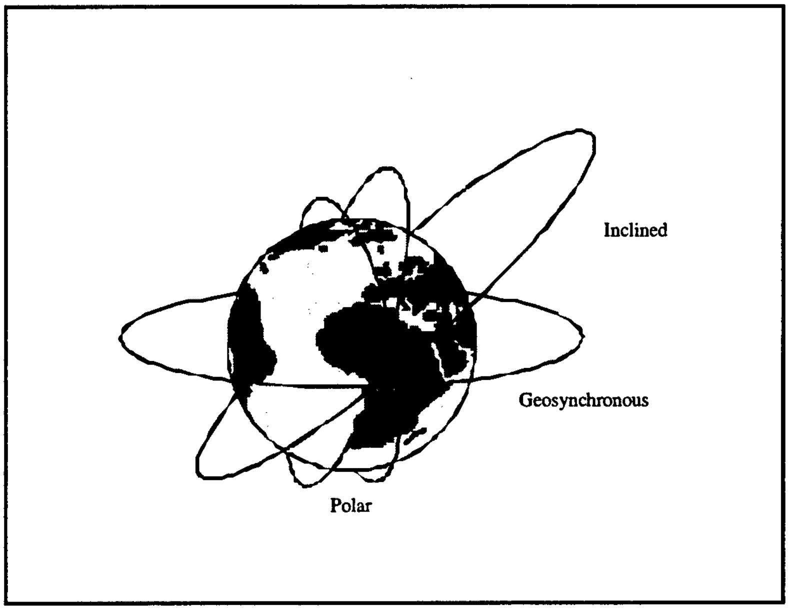


Figure 9—Types of Orbits

Geosynchronous Orbits

A geosynchronous orbit appears to always be in the same position with respect to a person standing on the ground. A GEO satellite orbits at an altitude of approximately 35,800km (22,250 miles), which aligns the satellite orbit period with the rotation of the Earth. By synchronizing a satellite with the Earth's rotation, the satellite tracks above the equator and appears stationary (hence the title geostationary) in its orbit. In reality, it is technically impossible to develop a perfectly circular orbit with a 24-hour period and an inclination of 0°. On the practical side, the ground track of these orbits offers ideal wide area coverage with the exception of polar views for monitoring weather or storm systems. Since a GEO sits over the equator, the polar perspective is distorted and the polar views are not reliable. Along with the viewing advantage presented by GEOs, these orbits are optimal for communications. Since receiver satellite dishes can be pointed in one direction, ground stations are not forced to track its host satellite across the sky. Currently, there are approximately 200 satellites that now inhabit geosynchronous orbits. (22 Jun--spof.gsfc.nasa.gov/stargaze/Sorbit.htm)

Polar Orbits

Polar-orbiting satellites circle at near-polar inclination and are considered sun-synchronous with a 90-minute orbit period. These satellites track within a few degrees of the poles (95-105° inclination) and cover some of the world's hard-to-see locations. Sun-synchronous orbits pass overhead at the same solar time every day offering a distinct viewing advantage. Photographic images can be scanned at the same time every day presenting analysts with consistent sunlight. This image consistency helps regulate data collection and enhances analysis opportunities.

Inclined Orbits

Inclined orbits are just that--they have an inclination with respect to the equator. Ranging between 0 degrees (equatorial orbit) to 180 degrees (retrograde equatorial), these orbits are initially determined by the latitude of the launch site and can be altered with expensive fuel burns to change the satellite's orbit profile. Orbit altitudes range from only a few hundred kilometers to the high earth orbits region. Inclined orbits cross various points on the Earth's surface at varying times and unlike sun-synchronous orbits, do not have consistent sun angles. An unique inclined orbit called Molniya is a highly elliptical orbit with a 62.4-degree inclination and was first used by the Soviets for early warning. The Molniya repeats its ground track ever 12 hours, hangs in the sky for extended periods during its apogee and is ideally suited for viewing the launch of any long-range missiles over the poles.

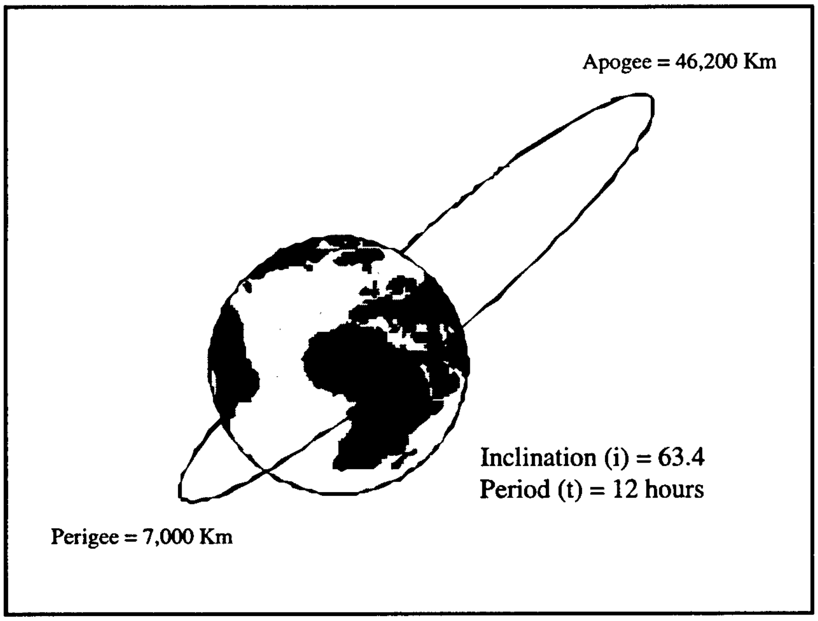


Figure 10—Molniya Orbit

WHAT MISSIONS ARE BEST SUITED FOR EACH ORBIT?

Today's satellite missions can be separated into four distinct categories under communications, navigation, surveillance, and reconnaissance. Eventually, direct attack may also become a unique mission. However, for the time being, satellite missions involve only four distinct categories each with specific characteristics. Table 3 summarizes the typical orbit profiles and the associated missions.

Table 3

Satellite Profiles

Categories	Orbit Type	Altitude	Period (hours)	Inclination (degrees)
Communication Television	Geostationary	High	24	0
Navigation Global Positioning	Semi-synchronous	Medium	12	55
Surveillance Early Warning	Molniya	Low-High	12	62.4
Reconnaissance Remote Sensing	Sun-synchronous	Low	1.5	95

Source: (Sellers 1996, p44)

Internationally, over 30 nations have developed some type of national space program involving either commercial or military missions. A decade ago,

space belonged to those who had the technological know-how and fiscal resources to maintain a space program. Today, the circumstances are much different. Many nations, as well as commercial enterprises, have entered the space arena because it has become affordable and more importantly, a national necessity. Table 4 offers a cross-section of the variety of nations and organizations that have satellites in orbit and the associated missions.

Table 4

Satellite Missions

Mission	System Name	Sponsor	Orbit
Surveillance	SPOT	French	LEO
Weather	GOES	DOD/NOAA	GEO
Weather	DMSP	DOD/NOAA	LEO-Polar
Imaging	RADARSAT	Canada	Polar
Imaging	Viking	Sweden	Polar
Imaging	LANDSAT	NOAA	LEO-Polar
Observation	EOS-Terra	NASA	LEO-Polar
Navigation	GPS	DOD	MEO
Communication	DSCS	DOD	GEO
Communication	Iridium	Commercial	LEO
Communication	Globalstar	Commercial	LEO

3. COMMANDS, AGENCIES, AND NATIONAL ORGANIZATIONS

Space has not been blessed with a concise, well-defined organizational heritage. Since the late 1950s, our national space program has matured despite the stovepipe organizations, which competed for limited resources and executed a national space program replete with redundancies and inefficiencies. Some would argue that our national space organization has been marred by decades of reactive vision and organizational claim staking. Those negatives aside, the Space Act of 1958 added some formality to our space architecture. It structured our national space program with the National Aeronautics and Space Administration assuming the civil lead while DOD had oversight for military specific programs. Although this alignment added some organization framework, many of the missions and programs were still scattered through a variety of government agencies and the DOD.

SPACE SECTORS AND OUR NATIONAL GOALS

Over the last decade, the binary NASA/DOD space program saw the dramatic rise of the commercial sector as a partner in establishing requirements and shaping policy. With profit motivation and technical opportunities at hand, the commercial space industry rose to a partner status and unwittingly redefined the organizational framework of our national space program.

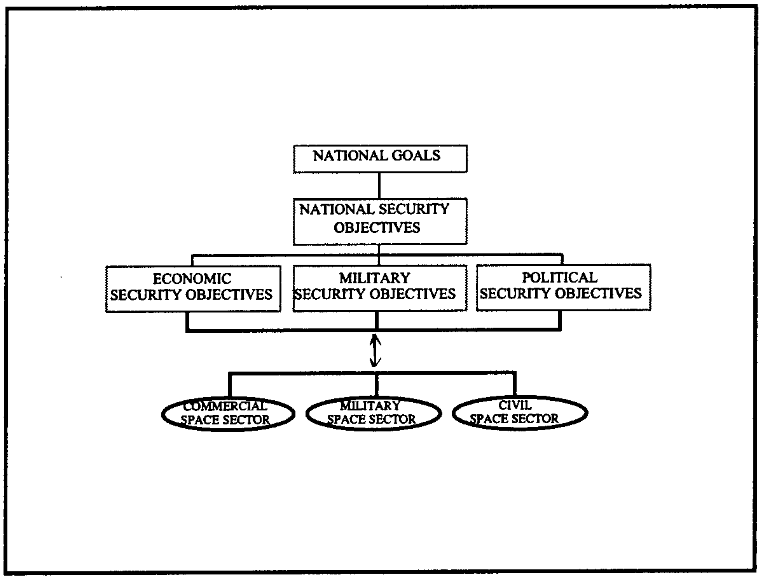


Figure 11—Space Sectors and National Goals

Along with commercial partnering, many recent internal improvements have consolidated and streamlined the space program. As Major General William Jones cited in the "White Paper of Space in the USAF," the notion of self-sufficiency was an institutional part of force structure planning and posturing that has given way to enlightened discussions and dialogue. (Jones, circa 1996, p2) Inefficiencies and redundancies have been reduced and most importantly, many organizations have developed strong supportive and co-existing relationships throughout the government. Rather than following the old style of grabbing projects and budgets, the DOD in concert with NASA, other government agencies and industry have deconflicted areas of responsibility, reduced overlapping responsibilities, and minimized resource competition. Yet, most importantly, these one-time stovepipe organizations are now beginning to pursue a cooperative relationship in promoting the national space agenda.

USSPACECOM ASSUMES STEWARDSHIP ROLE

From the military perspective, command framework has matured significantly with the stand-up of U.S. Space Command in 1985. USSPACECOM, a combatant command and one of nine unified commands, comprises three component commands from each of the services--United States Navy Space Command (NAVSPACECOM), United States Army Space Command (ARSPACE), and 14th Air Force

(part of Air Force Space Command or AFSPC). Labeled the first space command in the world (74: Colleen's Military Space Forces), USSPACECOM's chain of command runs directly from the Commander in Chief (CINC) to the Secretary of Defense (SECDEF) and then to the President.

The missions of USSPACECOM include supporting North American Defense Command (NORAD) with their missile warning and attack assessment mission, conducting space operations, and supporting the theater warfighters. These missions are conducted in a joint manner incorporating personnel and assets from each of the services--Navy, Army, Air Force, and Marines.

Navy Space Command, headquartered in Dahlgren, Virginia, was established in 1981 in order to consolidate the Navy's direct space support to Fleet and Fleet Marine Forces around the world. The Navy recognized its growing dependence on space and took broad measures to integrate its functions within USSPACECOM as a component command. The NAVSPACECOM functions with the Navy's space interests in mind. Aside from providing a continuous tactical intelligence link to its deployed forces through the Naval Space Operations Center (NAVSPOC), NAVSPACECOM also runs the Alternate Space Control Center (ASCC). The ASCC serves as a backup to USSPACECOM's Space Surveillance Network (SSN) which tracks all man-made objects in space. NAVSPACECOM co-located operations at Dahlgren with the Naval Surface Warfare Center (NSWC) and the Naval Space Surveillance Center (NSSC) have consolidated key space operations and enhanced the synergy of naval space organizations. (navspace.navy.mil/pao/nswc.htm)

Army Space Command (ARSPACE) is the operational command of the Army's Space and Missile Defense Command (SMDC) as well as the component command of USSPACECOM. ARSPACE is headquartered in Arlington, Virginia, with a "forward" presence at USSPACECOM. The Army has been involved in the space program with a history stemming back to the Redstone Arsenal days in the fifties. Much like the Navy, the Army is consolidating its space programs to support the warfighters in the field. Current programs focus on exploiting tactical communication, landmass analysis, navigational positioning, attacks warning and command and control (C^2).

AIR FORCE SPACE COMMAND MISSIONS

Air Force Space Command which is headquartered at Peterson AFB in Colorado has three direct reporting units (DRU): 14^{th} Air Force (14AF), 20^{th} Air Force (20AF), and the Space Warfare Center (SWC). 14AF at Vandenburg AFB, California, acts as the Air Force component command to USSPACECOM providing space warfighting forces. Additionally, 14AF manages the generation and employment of space assets for NORAD. 20AF at F.E. Warren AFB, Wyoming, provides the ICBM forces for the unified command STRATCOM, and the SWC at Schriever AFB, Colorado, develops new tactics for current and leading edge space systems.

With these three DRUs, AFSPC has four primary missions: space support, space control, force enhancement, and force application. The missions are undergoing doctrinal metamorphosis but today's missions include these responsibilities:

- Space support - launch military and high value payloads
- Space control - conduct counterspace operations which include surveillance, negation, and protection
- Force enhancement - provide weather, communication, intelligence, missile warning, and navigation capability
- Force application - maintain a rapid response ICBM force

Under the banner of these four missions, AFSPC operates within a broad framework outlined in our national space program.

Space Support

Space Support or more aptly, launch support, is the foundation of our space program. Without a robust ability to launch, we cannot gain access and maintain our presence in space. Spacelift is an integral part of the support mission that includes four different unmanned booster systems, the Space Shuttle, as well as the future development of Evolved Expendable Launch Vehicle (EELV). Along with launching payloads and satellites into orbit, another vital aspect of the support business is the command and control of those satellites. Many satellites require frequent monitoring and updates to optimize orbits and enhance mission performance. Without this 24-hour monitoring, many of these satellites would fall back to earth or become worthless space debris.

Space Control

Space Control is currently the hot button of AFSPC's missions. Much like the old principle of freedom of the seas, space control finds itself positioned as the guarantor of our freedom of action in space and more importantly, denying such freedoms to our enemies. There are four key aspects to space control: surveillance, protection, prevention, and negation. Surveillance involves detection, identification, and cataloguing over 10,000 man-made space objects that threaten our active satellites and orbit platforms. As the space race heats up, AFSPC has also focused on protecting our valuable inventory of satellites. An extremely difficult mission, which has only received recent attention, system protection includes building a survivable inventory with improved maneuverability, hardening and redundancy. In order to guard our technology advantage in space, prevention or denying enemy access to our systems with programs like Navigation Warfare (NAVWAR) and shutter control will definitely help preserve our space advantage during conflict. However, the last aspect of space control raises extremely sensitive issues because it involves offensive options. Negation refers to attacking an adversary's space capabilities such as his ground stations, the link to space, or the space system itself. The legal and political handcuffs surrounding negation have made this mission extremely contentious and a hotbed of debate.

Force Enhancement

Force enhancement provides the warfighter with critical space needs at the right time and place. Of all AFSPC's current missions, force enhancement offers the most obvious payback for today's airmen and warriors. The key elements of force enhancement include a laundry list of benefits in navigation and communication with respect to military operations. Listed below are some of the programs that provide dramatic leverage for our warfighters.

- Global Positioning System (GPS) - constellation of satellites providing 24-hour 3-D positioning for precise targeting accuracy
- Fleet Satellite Communications (FLTSAT) - ultra-high frequency (UHF) voice communications for Navy C2

- Defense Satellite Communication System (DSCS) - provides super-high frequency (SHF) voice and data capability
- Milstar - provides extremely-high frequency (EHF) voice and data capability
- Defense Meteorological Satellite Program (DMSP) - provides real-time weather data
- Defense Support Program (DSP) - provides theater missile warning and launch indication for operational forces

Force Application

Force application is fairly straightforward in today's weaponry vernacular. With our current land based nuclear deterrent force, the ICBMs under 20th AF, serve as a deterrent force against an adversary's ICBM attack. Our National Command Authority (NCA) can respond to such an attack by launching either 20th AF ICBMs or the Navy's Sea Launched Ballistic Missiles (SLBMs) which transit through space enroute to enemy targets. However, force application is really the great as-yet undeveloped future mission area for space. Still in its technological infancy, it holds tremendous potential as new systems and capabilities arrive on the warfighting front. With the evolution of space weapons such as the Space Based Laser (SBL) and energy directed weapons, force application will take on a whole new dimension. Much like the current turmoil surrounding the offensive nature of space control, force application looms as the debate of the future. In all likelihood, our power projection capability will eventually include force application from space, not simply through it.

USSPACECOM CINC SPEAKS WITH A SINGLE VOICE

CINC USSPACECOM also acts as the CINC of two additional commands - the North American Defense Command located in Cheyenne Mountain, Colorado, and Air Force Space Command headquartered at Peterson Field, Colorado. Due to the overlapping nature of each of these commands, this "triple hat" arrangement helps the CINC ensure unity of command and offers one voice for the military's space requirements and related issues.

NORAD is a bi-national U.S. and Canadian command and is responsible for the defense of North America using satellite sensors throughout North America to provide warning, surveillance, and command and control. This warning

apparatus involves both the Canadian Defense Forces as well as the 1^{st} AF in the continental U.S. Primarily a warning and assessment relationship with some air forces to protect against aerial attack, NORAD has no means to defend against a ballistic missile attack. Section 4 summarizes applicable treaty limitations and anti-ballistic missile defense restrictions.

Since USSPACECOM has become our nation's military space shepherd, each of the services integrates their component resources and personnel under this unified command. However, the move toward jointness has been slow in coming and the impediment of parochialism and service rivalries still remain within the DOD. When one dissects the areas of responsibility of each component command and remembers the inherent resource competitiveness that resides within the services, it is easy to see how the functional divisions have slowed progress toward space integration among our services.

THE CONTENTIOUS SPACE AREA OF RESPONSIBILITY (AOR)

USSPACECOM defines space as the fourth medium of warfare. Accordingly, USSPACECOM can act as either a supporting command or a supported command depending on the demands of the conflict. Generally, USSPACECOM provides space support for the geographically oriented unified commands which cover five distinct theaters. Each combatant CINC controls the air, land, and sea forces within the geographic confines of a particular area of responsibility and in turn, relies on space support from USSPACECOM. The AOR depicted in Figure 12 provides for a distinct space arena well above the respective geographic theater and its component forces. This space AOR is not a universally accepted definition and has not been incorporated in the Unified Command Plan (UCP). In fact, the space AOR concept has met bold resistance from the geographic CINCs and represents another key hot-button issue. However, it is important to recognize that USSPACECOM has drawn a line in the sand with its Long Range Plan and its conceptual boundaries between air and space.

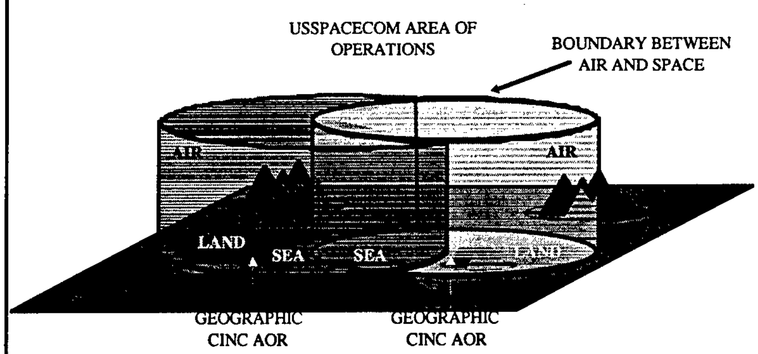


Figure 12—Space Area of Responsibility (AOR)

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

Whereas USSPACECOM is the space arm of the DOD, the National Aeronautics and Space Administration serves our nation's civil counterpart. From 1915 until 1958, our only government space organization was the loosely defined National Advisory Committee for Aeronautics. With the passage of the National Aeronautics Space Act of 1958, NASA became our single point clearing house for air and space research and likewise, assumed responsibility for all activities involving the manned and unmanned exploration of space. NASA's far reaching responsibilities involve coordinating research contracts and programs with numerous private enterprises, coordinating the multidisciplinary research among thousands of government scientists, engineers and technicians, and ensuring the effective operation of seven program offices and associated research centers:

Table 5

NASA Program Offices and Associated Research Centers

Office of Aeronautics and Space Transportation Technology
Ames Research Center at Moffet Field, CA
Dryden Flight Research Center at Edwards AFB, CA
Langley Research Center at Hampton, VA
Lewis Research Center at Cleveland, OH
Office of Life and Microgravity Sciences and Applications
Earth Science Enterprise
Goddard Space Flight Center at Greenbelt, MD
Space Flight
Lyndon B. Johnson Space Center at Houston, TX
John F. Kennedy Space Center at Cape Canaveral, FL
George C. Marshall Space Flight Center at Huntsville, AL
John C. Stennis Space Center at Stennis Space Center, MS
Space Science
Jet Propulsion Facility (Government-owned/contractor operated) at Pasadena, CA

With NASA and the DOD on the point, the National Reconnaissance Office (NRO), National Oceanographic and Atmospheric Administration (NOAA), and the National Imagery and Mapping Agency (NIMA) have also discovered newfound organizational integration in the national space program. The NRO and NOAA have emerged as valuable partners rather than resource competitors. A White Paper on "Space in the USAF" recognized that interagency consensus was a growing reality and that "outside organizations were becoming increasing parts of the space equation." (Jones, circa 1996, p2)

4. INTERNATIONAL AND DOMESTIC SPACE LAW

Space law may seem something better left to those barristers who enjoy laboring over obtuse nonspecific manuals and documents. Realistically, the generalities in our domestic and international space agreements have a tremendous impact on the shaping of our national policy and subsequently, space doctrine. Our national interests are best served by those who understand the legal precepts that underpin the laws, both domestic and international, which guide our space road map. This section will outline the key body of laws and directives, which shape our space policy.

PRINCIPLES OF THE UNITED NATIONS CHARTER

The chronology of space law found its beginnings with the original United Nations (UN) Charter in 1947. Many of the general principles ascribed in the charter have found their way into the fabric of modern space law. In simple terms, the UN Charter required all nations to settle disputes peacefully, prohibited using force to gain a territorial advantage against another state, and most importantly defined a state's right of self defense. Under these broad principles, the following de facto space laws became a template for the ensuing space race between the United States and the former Soviet Union:

- Space is not subject to any sovereignty claims.
- Space, like the high seas, is available to any nation.
- Space can only be used for peaceful purposes and the orbiting, installation, or stationing of weapons of mass destruction (WMD) are specifically prohibited.
- Space objects must be registered with the United Nations.
- A country is responsible for its space objects, albeit government or commercial, and any corresponding liabilities.
- A country may not build military bases or conduct military maneuvers on celestial bodies.
- The U.S. and Russia cannot deploy a space based anti-ballistic missile system.

THE OUTER SPACE TREATY (OST) OF 1967

The legal regime of space was manifested in the UN Charter but has since taken on details which give nations "wiggle room" to tailor and expand their national space programs. In the wake of the Cold War, the international community under the generalist notions of the UN Charter, adopted the Outer Space Treaty of 1967. This agreement serves as the cornerstone of international space law and transposes the broad principles of the UN Charter into a space genre. Its preamble recognized "the common interest of mankind in the progress of the exploration and use of outer space for peaceful purposes."

Reiterating many of the same principles endorsed in the original UN Charter, the OST also addressed the authorized use of force and the right of self-defense. Furthermore, the OST prohibited WMD in earth orbit as well as any fortifications on celestial bodies like the moon. However, there is a subtle divergence in the majority countries' interpretation of the phrase "WMD". Most significant is the general view of WMD as weapons that indiscriminately kill large numbers of people. This broad definition tacitly allowed such space weapon systems as the Space Based Laser and the Anti-Satellite System as long as the systems capabilities did not entail indiscriminant mass killing. In essence, OST opened the door for potential militarization or weaponization of space. Although supportive of man's peaceful use of space, the U.S. interpretation of OST did not link peaceful to non-aggressive. As such, the U.S. majority view of the term "peaceful purposes" included non-aggressive activity such as measures of self-defense, space-base reconnaissance, surveillance, communication, navigation and early warning. (Kelly 1996, p3)

THE LIMITED TEST BAN (LTB) AND ANTIBALLISTIC MISSILE (ABM) TREATIES

Two other treaties germane to this discussion were The Limited Test Ban Treaty in 1963 and the Antiballistic Missile Treaty in 1972. Both of these treaties were by-products of the Cold War and dramatically influenced the international course of space doctrine and policy. Designed to keep the burgeoning weapons race from literally exploding, the LTB Treaty prohibited nuclear weapons testing in air, sea, and space. On the other hand, the ABM Treaty involved only two signatories, the U.S. and USSR, and prohibited the

development, testing, and deployment of space-based ABM weapons. Originally intended as the death knell for any national missile defense (NMD) program, the ABM Treaty has come under recent scrutiny. The fall of the Soviet Union and rise of third world missile threats has energized NMD proponents and U.S. political actions have shown strong support for a NMD initiative. Interestingly, the ABM Treaty did not prohibit theater missile defenses (TMD) and in light of the Desert Storm SCUD attacks, our national priority has taken aim at developing a TMD to protect our deployed forces.

Another important provision of the ABM Treaty clearly prohibited interference with a nation's technical means of verification. This provision was a predominant stabilizer in the arms race because it gave both nation's the inherent right to witness an adversary's treaty compliance from space without any notion of threat. It also opened space as a medium for all nations to monitor an adversary's military posture without interference and thereby, assess intentions.

It is also important to understand some of the subtleties of treaty interpretation and that impact on our space policies and national decision making. U.S. treaty compliance has historically been based on what is specifically prohibited; accordingly anything not prohibited is permissible. This general rule of treaty interpretation would allow for weaponization of space and benefits DoD since most systems under development such as the SBL are not specifically prohibited. Another important sidenote, generally, the U.S. obligation to honor treaties applies only to peacetime circumstances. During hostilities and armed conflict, treaty tenets and articles may be disregarded and the military may move aggressively into the space medium, unless the specific terms of the treaty indicate that the treaty is to apply during times of conflict.

ADDITIONAL INTERNATIONAL AGREEMENTS

The UN Charter and the OST provided a foundation for international cooperation as technology built a bridge into space. Additional agreements such as the Rescue and Return Agreement (1968), the Liability Convention (1974), the Registration Convention (1974), the Environmental Modification Convention (1977) and the Constitution of the International Telecommunication Union (ITU) (1992) provided details to the general principles and overarching

themes. As this body of law expands and matures, so will the complexity of the space language. Liabilities from falling satellites, conflicting orbits, and harmful frequency interference will only serve to tighten these laws and eventually force the international community into agreement with regard to the management of space assets and corresponding systems.

DOMESTIC SPACE LAW UNDER PRESIDENT KENNEDY

No doubt, the evolution of our domestic space law has been influenced by international events such as the launch of Sputnik, but it is more directly related to powerful consequence of congressional budgetary outlays and presidential directives. President Kennedy rallied the nation under a banner of prestige and leadership as our space program took on the challenge of landing man on the moon by the end of the 1960s. In the aftermath of that successful mission, our national space program was massaged into our domestic priorities and quite often, space did not fair well on the congressional budgetary front. Although Presidents Johnson, Nixon, and Carter supported the principles of the U.S. Space Act of 1958, our national focus was not directed toward space.

DOMESTIC SPACE LAW UNDER PRESIDENTS CARTER AND REAGAN

While initially holding course with respect to space policy, President Carter issued a 1978 Directive on Space Policy which marked a turning point for the military. Under this directive, President Carter quietly signaled a shift in our national appreciation of the military potential that space offered. No longer simply echoing the military's space enhancement role, this directive gave hint to the radical view of force application from space. President Reagan vocalized this view during his second term when he boldly crossed the sacrosanct line of force enhancement and force application with the long-term objective of eliminating the strategic threat from ballistic missiles with the creation of the Strategic Defense Initiative. (Space Reference Guide, p17-6)

DOMESTIC SPACE LAW UNDER PRESIDENTS BUSH AND CLINTON

Presidents Bush and Clinton further refined our national space policies and streamlined a somewhat fragmented national organizational structure. Reaffirming our role as leaders in space exploration, President Bush

reiterated that our space activities were distributed along three lines: military, civil, and commercial. Competing interests, which seemed to plague the early space program, were minimized with improved exchanges and separation of responsibilities. This treble apparatus helped redefine the national space program and ensured that the organization was prepared to keep pace with space developments and the economic viability of space systems.

1996 NATIONAL SPACE POLICY

The 1996 National Space Policy outlined by President Clinton was not a revolution in space policy. Rather, the document repackaged the same goals summarized in the National Space Act of 1958 and updated them in the context of current commercial and military landscapes. Although a bit dusty, these five goals still articulate our national space agenda:

- Knowledge by exploration
- Maintain national security
- Enhance competitiveness and capabilities
- Private sector investment
- Promote international competition

Along with these overriding goals, there were four key areas which separated and deconflicted agency tasks and responsibilities: civil space, national security, intelligence, and commercial space. These areas were aligned under respective government organizations and specific guidelines established to ensure efficient span of control without conflicting resource allocation. Table 6 summarizes those key areas, lead agencies, and assigned tasks.

Table 6

Key Areas and Tasks of Lead Space Agencies

Key Area	Lead Agency	Tasks
Civil Space	NASA	Develop International Space Station Develop next generation Reusable LVs
National Security	DOD	Improve support of military operations Maintain capability in space support, force enhancement, space control, and force application Develop next generation of Expendable LVs Integrate satellite command and control Develop a Theater Missile Defense capability
Intelligence	DCI	Conduct peaceful photo-reconnaissance Provide timely information to support NCA Provide warning indication, crisis management and treaty verification
Commercial	Dept of Commerce	Enhance U.S. economic competitiveness Stimulate private sector investment

5. PRIORITIES, STRATEGIES, AND DOCTRINE

Our maturing national perspective on space can best be summarized in an excerpt from the 1998 National Security Strategy for a New Century,

> "We are committed to maintaining our leadership in space. Unimpeded access to and use of space is essential for protecting U.S. national security, in promoting our prosperity and ensuring our well being in countless ways. Space has emerged in this decade as a new global information utility with extensive political, diplomatic, military and economic implications for the United States. We are experiencing an ever-increasing migration of capabilities to space as the world seeks to exploit the explosion in information technology. Telecommunications, telemedicine, international financial transactions and global entertainment, news, education, weather and navigation all contribute directly to the strength of our economy--and all are dependent upon space capabilities." (National Security Strategy for the New Century, p25)

In order to understand the issues that are shaping space doctrine, one must understand our national space priorities and strategies. As mentioned is Section 4, Presidential directives have shaped our space program since Sputnik shocked America in 1961. Ironically, our national leadership has not always been blessed with a clear vision of space and its potential. Hence, our national priorities have often vacillated in direction and purpose. It is no wonder that we have moved to the end of the 20^{th} century with no clear-cut space doctrine to guide our operational and tactical warfighting principles.

NATIONAL FOCUS IN THE AFTERMATH OF APOLLO 11

After landing on the moon and reclaiming the scientific high ground against our Soviet adversaries, President Nixon put our space objectives under a fiscal microscope and congressional inclination shifted away from big budget outlays required of a serious national space program. Instead of well-defined long-term objectives driving our space program, space initiatives became terminally linked to fiscal decisions and overridden by congressional interest

in domestic issues. Yet, even amidst this waning support, several keynote programs such as the Defense Meteorological Satellite Program, Defense Support Program, Defense Satellite Communications System came to fruition. These programs along with NASA's Space Transportation System (STS or space shuttle) helped the U.S. maintain a developmental lead and technological edge on the international space front.

Space programs were no longer the favorite political child of Congress. Consequently, space policy languished for much of the 1970s and 1980s. President Carter piqued the military's interest with a subtle policy shift hidden deep within the text of Presidential Directive 37. Traditionally, the military had accepted its role in space as a force enhancer but now, President Carter's PD-37 reflected a resurgent determination to use space as a means to ensure national security. With the ever present Soviet ICBM threat, space offered a leverage to the military. For the first time, our national leadership acknowledged a willingness to develop an anti-satellite capability and in short, consider space a warfighting medium. (Muolo 1993b, p61) This policy shift became even more pronounced under President Reagan who boldly announced the Strategic Defense Initiative in 1986 moving the military from tacit force enhancers to force enablers.

Clearly, the U.S. space program lost momentum in the wake of Apollo 11 and our landing a man on the moon. During the post-Apollo 11 letdown, NASA did a formidable job optimizing limited resources while the DOD quietly protected our critical space technological outposts. However, it was Reagan's SDI and STS proclamations that reenergized our national space program--both civil and military. The 1980s saw international agreements and our domestic space policies follow an evolutionary and increasingly interrelated course. While the Shuttle garnered headlines, the DOD inadvertently laid the seeds of doctrinal development that now preoccupy the national and military space debate. Today, USSPACECOM stands at the forefront of our national space challenge. Acting as the lead spokesman for doctrine and future military space requirements, USSPACECOM is at a crossroads and mired in a state of vigorous upheaval.

AF Doctrine Document 1 published in 1997 offered the first serious attempt at adding doctrine into our space curriculum by integrating space into traditional airpower doctrine. AFDD 1 turned the tide for theorists and

provided a fundamental framework for operational strategists and hands-on tacticians. It is important to remember that AFDD 1 was not the doctrinal lexicon for warfighters and users of space. Rather, it was an attempt at bringing space doctrine to print. Rudimentary in scope, it comprised an amalgam of lessons and experiences, technological breakthroughs and visionary ideas on how to make the most of American aerospace power in the event of another conventional war. As one can imagine, these doctrinal tenets are undergoing a storm of ideas and change. Understanding this reference point and acknowledging these dynamics is essential for engaging in future discussions on space's national priority. The historical dialogues of our national and military strategies are key ingredients to shaping our doctrinal perspective.

1998 NATIONAL SECURITY STRATEGY

President Clinton's 1998 National Security Strategy (NSS) reaffirmed and clarified our interest and commitment to maintaining our leadership in space. A capstone document, the NSS outlined the elements necessary to ensure our economic, military, and political success in the 21st century. Reiterating the ideas of past Presidential Directives, the Clinton's National Security Strategy hinged success on our ability to fully integrate space development into the national agenda. The key elements of this National Security Strategy, as related to space, were:

- Unimpeded access to and use of space is essential to national security
- Deter anything that threatens our access to and use of space
- If necessary, defeat any hostile effort to our access and use of space

Simple and to the point, these elements are also embedded in our 1997 National Military Strategy.

Striving to maintain a technological lead in space is paramount to the military's ability to operate its land, sea, and air forces to greatest effect. As the world globalizes and the advantages of space proliferate, more nations are developing competing capabilities and challenging many of our once unique military advantages. As such, our ability to guarantee access to and use of space could eventually be in jeopardy. Consequently, space priorities are gaining increasing importance, especially within the scope of joint military operations. Much like freedom of seas evoked the rise of powerful

navies, so too will the concern for freedom of action in space drive nations to build systems that protect this new medium.

AIR FORCE 2025

In 1996, the Chief of Staff of the U.S. Air Force, General Fogleman, responded to a rapidly changing landscape and initiated a comprehensive study called Air Force 2025 to look 30 years into the future and identify concepts, capabilities, and technologies necessary for the U.S. to maintain air and space superiority. The conclusions of this futurist study built a framework around five alternate futures ranging from a constrained U.S. military to a world marked by fundamental changes in today's social, environment, and international security system. Through all the analysis and predictions, it was clear that space was assuming the preeminent role. Of the top ten capabilities and high leverage technologies expected to influence alternate futures, most were directly or indirectly connected to the medium of space.

Table 7

Top 10 Capabilities in Air Force 2025
Global Information Management Systems
Sanctuary Base
Global Surveillance, Reconnaissance and Targeting System
Global Area Strike
Uninhabited Combat Air Vehicle
Space High Energy Laser
Solar High Energy Laser
Reconnaissance Unmanned Air Vehicle
Attack Microbots
Piloted Single Stage Space Plane

Source: (www.au.af.mil/au/2025/quicklk.htm, 1999)

CAF 2025 was an analytical tool that highlighted potential trends and insights to our future warfighting capabilities. It argued that the future success of our Air Force as well as our military forces across the board hinged on the integration of information technologies and space capabilities. Most significant to doctrinal debate, AF 2025 argued that the medium for air force operations would move from air and space toward space and air, signaling a transition to space as distinct medium of warfare. This position has quickly emerged as a lightning rod for a great and fractious controversy in the Air Force.

USSPACECOM'S LONG-RANGE PLAN (LRP)

USSPACECOM, under truly visionary leadership, has grappled with the many uncertainties that typically face a new dimension of warfare. Many liken the prospective evolutionary path of U.S. space power to that of airpower in the first half of the 20^{th} century. In the beginning, airpower was seen by the leaders of the day as merely a force enhancer available to support the ground commander. Although a separate service, the United States Air Force struggled to define itself and its future doctrinal role. Arguably, technology helped airpower come of age during Desert Storm and yet, the airpower debate still creates a divisive atmosphere among the services. In any event, technology did bring airpower's potential full circle. Many feel technology will beat the same path for space. Eventually, space will move from its current role of force enhancement to one of dominant force application.

In fact, in 1997, the DOD concluded that space control architecture centered around denying enemy access to space capabilities such as communication, missile warning, navigation, weather information, surveillance, and missile targeting. More recently, the Joint Requirement Oversight Council recognized and approved the military's need for a space control mission, which has since ignited an intense service-specific requirement debate. (Inside the Air Force 1999, p2) This service debate is exacerbated by the fact that the Air Force now provides over 90 percent of the military space budget and amazingly, 93 percent of space personnel. (Ryan 1997) The lack of burden sharing only magnifies a sense of parochialism in the DOD. It signals a desperate need to clearly structure a balanced space program in which all benefactors--civil, commercial, and military--participate fairly and responsibly.

It is obvious that space doctrine is in an embryonic state. According to USSPACECOM's 1998 Long-Range Plan, we are at a critical crossroads and there are compelling circumstances affecting our national space program. Most noteworthy are two points which summarize the urgency and opportunity facing our nation: (Long-Range Plan Executive Summary, p2-3)

- No global peer competitors exist and we are in a "strategic pause" period where our military must capitalize on innovative warfighting concepts and clearly identify future requirements

- Our nation's growing economic and military dependence on space creates a dangerous vulnerability which demands a tremendous investment in protecting and securing access to and use of space

Ensuring our leadership in space and protecting our national interests has driven policymaker and strategist to the same table. Space has quickly become a center of gravity and needs keen attention at all levels. Policy, strategy, and doctrine all must be aligned in order to successfully address this new medium.

USSPACECOM'S VISION 2020

USSPACECOM has taken the visionary and operational lead for our nation. Within the context of Vision 2020, there are two principal themes which chart a path for USSPACECOM:

- Dominate the space medium
- Integrate space power

In order to achieve those goals there are four operational concepts that will ensure Vision 2020 is achieved:

- Control of Space
- Global Engagement
- Full Force Integration
- Global Partnership

Heightened concern about our space focus has been a popular policy issue in many recent studies. The Secretary of Defense Strategic Studies Group IV 1999 final report, "Premises for Policy: Maintaining Military Superiority in the 21st Century," highlighted two key points for the Department of Defense:

- DOD must ensure U.S. access to the critical dimension of space
- DOD must develop the ability to deny access to space (p21)

This report noted that space held a unique opportunity for both the U.S. and its adversaries but the growth of commercialization and outsourcing must be tempered with an ability to reconstitute access to space should commercial access be challenged. (Secretary of Defense Strategic Studies Group) Commercialization of space has clearly changed the dynamics of space and its shared use. Common assets shared by allies and adversaries alike create a precarious environment in which space and its options might be neutralized for all participants in future conflicts. The Strategic Studies Group recognized

the eventuality that the U.S. needed to invest in a means to neutralize space assets--both commercial and military. This points toward a range of options from selective denial of space assets to a robust capability to control and destroy space assets.

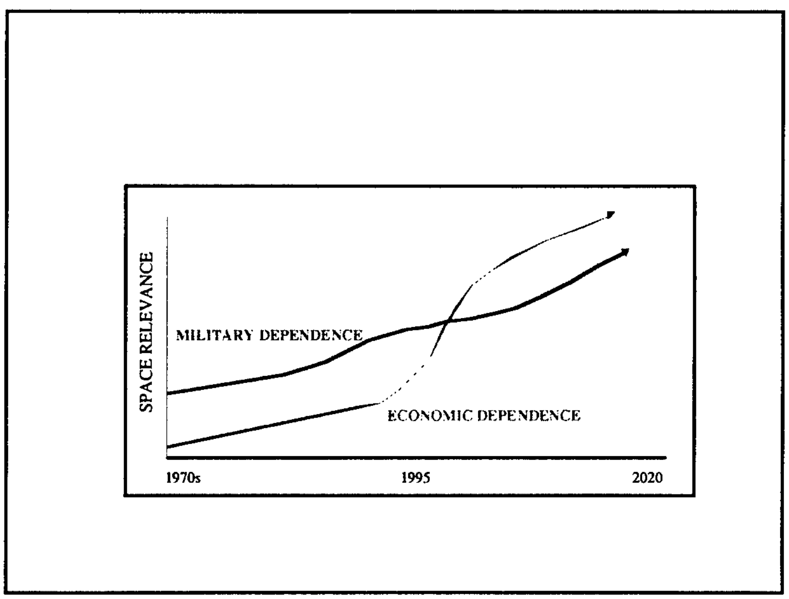
6. COMMERCIALIZATION OF SPACE

EVOLUTION OF COMMERCIAL DEPENDENCY

For decades the government and DOD have dominated space. Now, there is a dramatic shift in the players and participants. General Ryan, U.S. Air Force Chief of Staff, forecast a changing tide when he assessed the military's transition from a technology developer to a technology customer dependent on the commercial space industry.

> "Due to financial constraints and market forces, we may become as much of a technology customer as a developer relying on the innovative minds of the commercial sector and other agencies for many of our new developments for military use. We need a partnership with industry more than ever, and we are trying to do our part to foster that partnership. We believe our access to space goes hand-in-hand with commercial access to space." (Ryan 1997)

The challenge facing our nation rests with our ability to partner with industry and expand the links between classified and unclassified space programs, government and non-government agencies, civil and commercial enterprises as well as the uniformed services themselves.



Source: (USSPACECOM Long-Range Plan, p19)

Figure 13—Evolution of Commercial Dependency

This shift toward partnership and growing commercial significance was also a dominant theme in the President's 1998 Strategy for the New Century. There are over 500 U.S. companies directly involved in the space industry with projected revenues exceeding $120 billion by 2000. (National Strategy for the New Century, p25) Commercial industry has suddenly changed the investment profile of our nation and for that matter, the world's foray into space. During the heyday of the space race with the Soviets, high costs and risks precluded any significant commercial investment without government support. However, with the failure of the Challenger and the emergence of Arianespace, the outlook and growth potential for the commercial space industry took on a whole new dimension spawning an explosive market for prospecting investors and aggressive businesses. It is fair to say that space now belongs to the businesses and investors who wisely capitalize on rapidly advancing technologies and harness many of the virgin opportunities that space brings to our worldwide marketplace.

EMERGING TRENDS IN THE SPACE MARKETPLACE

There are dynamic trends shaping the space marketplace. Although the press tends to focus primarily on many non-commercial events such as Mir, the Space Shuttle, and Hubble, there are several key growth areas that deserve attention. According to the *State of the Space Industry 1998 Outlook*, the most significant trend focuses on the "emergence of direct-to-consumer applications such as mobile communications using satellites, direct-to-home satellite television, precision farming, expanded bandwidth broadcasting for data and Internet services, and directional assistance using GPS signals for civilian automobiles, aircraft, and boats." (State of the Space Industry 1998 Outlook, p4) The annual report offers a good overview of the commercial space industry's trends and successes, but more importantly it provides a snapshot of each segment of the commercial space industry which include these areas:

Table 8

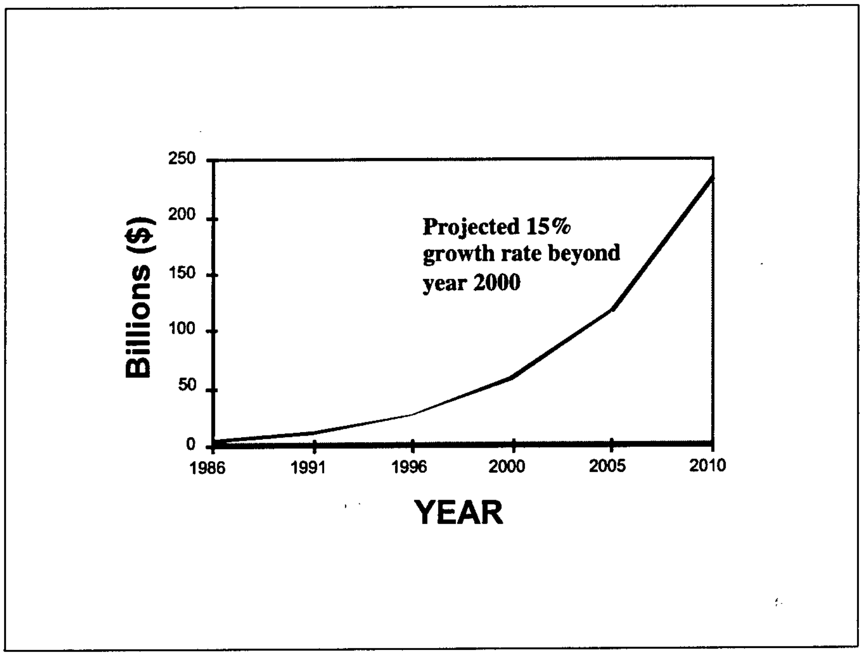
Segments of the Commercial Space Industry

Satellite Manufacturing
Expendable Launch Vehicles
Reusable Launch Vehicles
Ground Equipment
Telecommunications
Remote Sensing
Global Positioning System
Microgravity
Support Services and Finance
Government

Source: (State of the Space Industry 1998 Outlook)

This sector-by-sector review highlights how commercial space has moved from a sideline supporter of government and DOD space programs to an impetus force and technology shaper.

For many investors, the ideas and dreams of yesteryear are now within reach. Consequently, benefit outweighs the risk and many financial institutions are eager to contribute and support upstart businesses and emerging technologies. The proof is in the pudding; 1998 revenues for the space industry were $88 Billion with a projected 5-year growth of 48 percent and a total revenue forecast of a staggering $450 Billion. (State of the Space Industry 1998 Outlook, p8) Figure 14 tracks industry revenue projections through 2001 and highlights the level of confidence that space holds within the financial community.



Source: (Space and Missile System Center Briefing)

Figure 14—Commercial Space Market

In order to appreciate the magnitude of the commercial sector's involvement, one must first understand the industry segments that shape investment and research. Infrastructure and applications are the key nodes with which industry experts can categorize their programs and highlight potential benefits. Take a look at the Current and Planned Space Activities highlighted in Table 9. The diversity and breadth of the activities and the impact on our average consumer is remarkable. With such dynamic opportunity, there is little doubt as to the future role the commercial space industry will play in our daily lives.

Table 9

Current and Planned Space Activities

Telecommunications

Cable programming distribution
Live television and video transmission
International telephony mobile and wireless communications
Messaging services
Telemedicine
Tele-education
High-speed Internet access
VSAT private communication networks
Direct-to-consumer video and radio

Spacecraft Manufacturing

Telecommunications satellites
Remote-sensing satellites
Planetary-exploration spacecraft
Weather satellites

Launch Vehicles

Expendable launch vehicles
Reusable launch vehicles
Space-shuttle operations
Orbit transfer vehicles

Ground Equipment

Ground stations
Electronic receiving and transmission equipment
Antennas
Information technology
Computer software and hardware
High capacity data storage

Ground Operations

Satellite operations
Telemetry and control hardware and software
Health-monitoring and operations-planning software
Component-testing facilities
Launch-vehicle spaceports

Global Positioning System Services

Enhanced air-traffic control
Services for automobile navigation
Improved search and rescue devices
Real-time tracking and logistics for package delivery

Remote Sensing

Weather prediction and forecasting
Monitoring of the earth's environment
Searching for natural resources
Analysis of soil and land conditions for farming
Use of digital terrain maps
National security intelligence gathering

Human Space Activities

International Space Station, MIR
Space shuttle
Medical, physiological, and psychological research
Spacehab

Microgravity

Production of new or improved materials
Enhanced crystals for biomedical research
Biomedical drug development

Space Science

Astrophysics and astronomy
Astrodynamics
Cosmology
Astrobiology
Planetary exploration

Technology Research and Development

Optics and lasers
Power and propulsion systems
High-temperature materials, composite materials
Thermal control
Guidance, navigation, and control technologies
Robotics

Future Space Activities

Permanent lunar bases
Human Missions to Mars
Manufacturing in orbital facilities
Mining of nearby asteroids
Orbital solar-power generation stations
Toxic- and nuclear-waste disposal
Tourism

Support Services

Administrative support
Consulting and technical support
Legal and licensing
Financial services
Media and publishing
Satellite, launch vehicle, and in-orbit insurance

Source: (State of the Space Industry 1998 Outlook, p16)

THE FUTURE SPACE INDUSTRY AND ITS MARKET SHAPERS

By some estimates, there are tens of thousands of companies linked to the space industry. Following the major industries or "market shapers" offers a roadmap as to the future space business trends. According to the 1998 State of the Space Industry, the major industry sectors can be grouped into four distinct segments: infrastructure, telecommunications, space data, and space asset applications. (State of the Space Industry 1998 Outlook) Key infrastructure segments include satellite manufacturing, ground systems, and launch vehicles. Telecommunications markets include fixed satellite services, mobile satellite services, direct-to-home services, and broadband applications. The space derived data segment includes information-generating systems such as remote sensors, Geographical Information System (GIS), Global Positioning System (GPS), and space observatory data. Finally, space asset applications offer exciting new ventures in microgravity, tourism, robotic exploration, mining, and manufacturing in space.

Within the infrastructure segment, launch vehicles deserve special mention. The cost-per-pound of launching payloads has surfaced as a serious constraint to our national space expansion. In 1998, USSPACECOM declared reducing payloads costs per pound as its number one priority. Currently, the majority of our capability rests with our fleet of expendable launch vehicles (ELV) at a cost of approximately $10,000 per pound. With budget circumscriptions and limited resources affecting program bottomlines, both the DOD and NASA have taken serious umbrage with those figures. Intent on reducing launch costs to $100s per pound, new programs like Lockheed Martin's reusable launch vehicle—VentureStar--will hopefully achieve this fiscal objective in the near term.

Along with the launch market, the dramatic impact of telecommunications on our daily lives has put this market at the forefront of international concern. Categorized along the lines of fixed and mobile satellite services and most recently direct-home services, these areas represent the driving force influencing consumer demand. It is easy to look over our shoulder and witness how the market was shaped by demand. David Savold of Iridium commented, "Cellular phones were initially described as too challenging, too complicated, and too expensive…early cellular systems served only a relatively small number of people…Yet, prices declined in the succeeding generations as

the market increased." (State of the Space Industry 1998 Outlook, p47) Today, cellular phones are nearly an indispensable part of our commuting experience. Ironically, today's emerging mobile industry faces the same viable arguments that plagued the cellular industry ten years ago. Take note, as service improves and technology delivers, the mobile industry, both voice and data, is poised to make a quantum leap into the marketplace.

7. SPACE SYSTEMS TODAY

The earlier discussion of Air Force space missions addressed space support, space control, force enhancement, and force application. In order to appreciate current as well as our nation's future space systems, this section will introduce the major programs currently in operation, the ground-based architecture that supports those ongoing operations, and a brief summary of future programs as they relate to these Air Force missions. Aligning current and future programs with the aforementioned Air Force missions should add some clarity to the value of each system and its role in shaping our national security.

SPACE SUPPORT - LAUNCH OPERATIONS AND TRENDS

As discussed in Section 5, space support was described as the linchpin to our space program because it provides the capability to launch, deploy, operate, and sustain satellites. The two subsystems of space support are launch operations and satellite operations.

Launch operations are managed from a variety of sites which until recently were controlled by either NASA or the DOD. However, the move toward a mix of national space capabilities has seen the operation of many of the launch facilities shift toward commercial control and ownership.

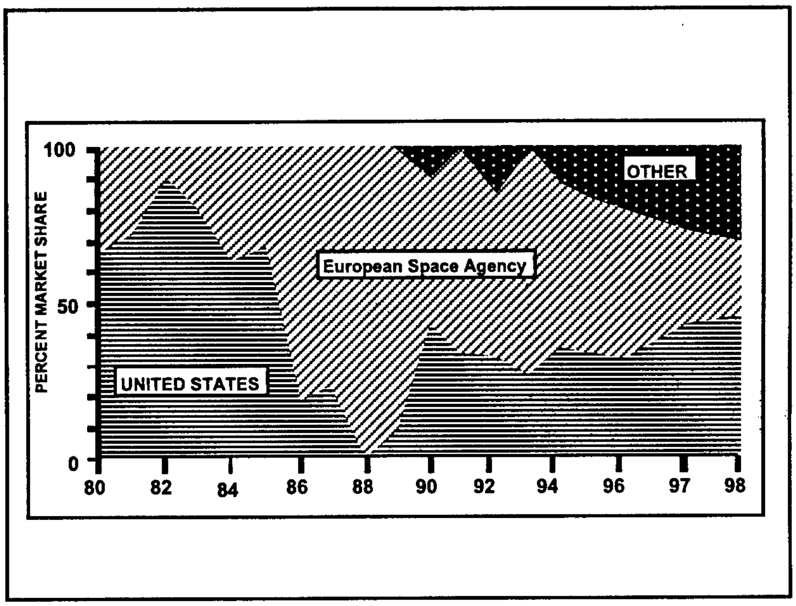
Table 10

U.S. Launch Facilities and Site Responsibility

Florida	Cape Canaveral AS John F. Kennedy Space Center Spaceport Florida Facility (at Cape Canaveral)	DOD (one of two military launch sites) NASA Space Shuttle launch site Commercial launch site
California	Vandenberg AFB California Spaceport Facility (at Vandenberg AFB)	DOD (one of two military launch sites) Commercial launch site
Virginia	Wallops Flight Facility Virginia Space Flight Center	NASA suborbital launch site Commercial launch site
Alaska	Alaska Spaceport Facility	Dual-use commercial launch site

These launch sites play a critical role in maintaining our access to space. Until the Challenger disaster in 1986, the U.S. clearly dominated

space access for almost all payloads. In fact, the majority of launches occurred at either Vandenburg AFB or Cape Canaveral. However, with the failure of the space shuttle and the subsequent freeze on the Space Transportation System, foreign governments and enterprises have garnered the lion's share of the market. Once unbeatable in space launch capability, the U.S. only has 36 percent of the annual launch market. (Air Force Magazine, Nov 1998, p42) Figure 15 depicts the abrupt end of the U.S. dominance of the launch market and the rise of foreign competition.



Source: (AFSPC Command Briefing, undated)

Figure 15—Launch Market Trends

The loss of Challenger was clearly a wakeup call for our national leadership. Our national policy of relying primarily on the STS while phasing out the military's expendable launch capability, was recognized as foolhardy and a threat to our national security. Since that Challenger tragedy, our space access has taken on a much more logical and balanced path. Now, our national capability is split between NASA's manned STS and AFSPC's current fleet of unmanned expendable launch systems.

Table 11

U.S. Launch Systems

Expendable Boosters	**Payload**
Delta II	Medium
Atlas II	Medium
Titan II	Medium
Titan IV	Medium/Heavy
Pegasus	Light/Light
Proposed Expendable Boosters	
Evolved Expendable Launch Vehicle (EELV)	Medium/Heavy
Taurus	Medium/Medium/Light
Conestega	Medium
Lockheed-Martin Launch Vehicle	Medium
Delta III	Medium
Delta Medium Light Expendable Launch Vehicle	Light
Reusable Systems (Manned)	
Space Transportation System	Heavy
Proposed Reusable Systems	
Reusable Launch Vehicle (RLV)	Medium/Heavy

Source: a. (Space Warfare Center Reference Guide)
b. (Worldwide Guide to Commercial Launch Vehicles)
c. (www.spacecom.af.mil/hqafspc/library/facts/gps.html)

Table 11 summarizes the current and proposed unmanned booster systems which provide a mix of medium and heavy spacelift capability. Balancing our launch capability between the reusable and expendable systems has helped the U.S. regain some ground since the Challenger loss. Nevertheless, the fallacy of placing complete trust in one system has been an expensive lesson.

NASA and the Air Force have linked arms in assuring the U.S. a reliable and low cost access to space. For NASA, Lockheed Martin's long-term solution is the VentureStar. This RLV is designed as lifting body intended to achieve LEO at costs of only $1,000 per pound versus the Shuttles current cost of $10,000 per pound. (42: Air Force Magazine Nov 1998) On the other hand, the AF is still in the business of building more efficient expendable launch vehicles. The Evolved Expendable Launch Vehicle (EELV) is the key component of the AF modernization initiative with the first expected launch scheduled in 2002. Designed as the follow-on for the current fleet of unmanned expendable boosters, EELV's improved operability and standardization should reduce launch costs by 25 percent and realize $6 billion in savings from 2002-2020. (Air Force Magazine, Nov 1998, p42)

The integration of space capabilities is also evident in development of future launch and control facilities. Many of our national launch facilities have fallen into disrepair and need serious upgrading. There are numerous initiatives to upgrade these sites and improve the efficiency operations. Consolidation, outsourcing, and joint-use agreements have signaled a healthy realignment of our space infrastructure.

SPACE CONTROL SYSTEMS

The current space control mission rests with our ability to protect space assets and ensure our space capabilities are not threatened. Critical to this mission is our ability to detect missile launches and provide warning for the National Command Authority in the event of a nuclear or ICBM attack. The U.S. Missile Warning System I is comprised of these current and planned systems:

- Space-Based Warning Sensors
- Defense Support Program (DSP)
- Space-Based Infrared System (SBIRS)
- Ground-Based Warning Sensors
- Ballistic Missile Early Warning System (BMEWS)
- PAVE PAWS

FORCE ENHANCEMENT SYSTEMS

The force enhancement mission has the most direct relevance in our personal lives. Many of the systems within our military space superstructure are shared or have similar civil and commercial identities. It is fair to say the space expectations for our combatant forces overlap the same commercial demands of the private sector. The benefits of space are forever interleaved within the fabric of military operations as well as our personal everyday life. Consequently, concurrent expectations have created a complex mingling of resources: military, civil, and commercial. Many navigation, communication, weather forecasting, and imaging ventures are matrixed with the military, civil, or commercial assets. The following tables identify the typical systems incorporated within the key force enhancement satellite networks:

Table 12

U.S. Satellite Navigation Systems

U.S. Satellite Navigation Systems
NAVSTAR GPS
Precise Positioning Service (PPS)
Standard Positioning Service (SPS)
Space Segment
Master Control Segment

Table 13

U.S. Satellite Communication Systems

U.S. Satellite Communication Systems
Military Satellite Communications (MILSATCOM)
Fleet Satellite Communications Systems (FLTSATCOM)
Defense Satellite Communications System (DSCS)
Military Strategic and Tactical (MILSTAR)
Air Force Satellite Communications System (AFSATCOM)

Table 14

International Weather and Environmental Satellite Systems

Weather and Environmental Satellite Systems
Optical Imagery
Defense Meteorological Satellite Program (DMSP) - DOD
Geostationary Operational Environmental Satellite (GOES) - National Oceanic and Atmospheric Administration (NOAA)
Television and Infrared Operational Satellite (TIROS) - NOAA

Table 15

International Multispectral Imagery Satellite Systems

Multispectral Imagery
LANDSAT - Earth Observation Satellite Company (EOSC) - U.S.
Satellite Pour L' Obserfation de Terre (SPOT) - France
Indian Remote Sensing Satellite (SIRS) - India
RADARSAT - Canada
European Remote Sensing Satellite (ERS) - Europe

8. MILITARY PROGNOSIS

There are many unknowns about space and how it will change the economic, political, and military landscape of the future. No doubt, the outlook from the military's perspective is wide open. The pathway twists with the innovations of technology and the directives of national policy. Intended as a paint-by-numbers tutorial, the previous sections of this paper offered the unschooled a chance to review some of the fundamentals underlying the development of space. This reading should serve as a first step in understanding the opportunities and potential afforded space users. As a template for future study, this Executive Guide to Space is merely a beginning.

Armed with a fundamental albeit enlightened understanding of space, it is appropriate to highlight some of the more relevant questions churning amidst political and military forums across the country. The interest in these issues is clearly gaining momentum in both military and civil circles. Wargaming exercises conducted by all the services point to many unresolved issues that impact our use of space and the potentially decisive advantage it brings to conflict. Strategists--both military and civilian--are focusing on questions that offer a multiplicity of choices and long-term consequences. In any event, as food for thought, these next few questions represent the forefront of space debate and are fertile ground for further study.

DO WE NEED A SEPARATE SERVICE FOR SPACE?

The often heated debate about space and its relationship with the other services is bounded by extremes. Positioned at one edge is the belief that space is and will always be a force enhancer inclined to support air, land, and naval combatant forces. In opposition are those who view space as a distinct medium and argue for a dedicated service component much like the Air Force, Navy, and Army.

The argument today finds space predominantly confined in a supporting role as a force enhancer. Desert Storm marked the first conflict where space supported the warfighter on a critical real time basis. However, the communication links, satellite images, and SCUD launch warnings during that

war merely enhanced the application of military force; at that time, technology did not offer any significant employable counterspace capability. Today, many still feel space has not matured enough and is handicapped by the unfilled promises of technology. Confined by techno-limits, this argument still holds space as a means to enhance our resident air-land-sea warfighting capability.

There is no immediate need for a Solomon-style decision about how we are organized and whether space deserves equal billing with the Air Force, Army, and Navy. However, as doctrine evolves and technology bears the proverbial counterspace fruit, space may well emerge as a distinct warfighting medium. The uniqueness of space is not, in and of itself, justification to activate a new service. "Military space operations, much like U.S. tactical air combat power, probably will remain a specialty within several services that squabble over respective budgets/prerogatives, until important space missions involve more than support for armed forces on earth." (82:Military Space Forces - The Next Fifty Years) For the time being, USSPACECOM is adequately positioned to manage our national space forces and maintain space in its supporting role over our fighting forces. Yet, within the next few decades, technology will most likely force our hand, create a new medium for warfare, and propel space into a new doctrinal arena.

HAS THE SPACE ARMS RACE ALREADY BEGUN?

The leverage that space brings offers tremendous economic windfall and military capability to any nation. The trend over the last decade has been much like a gold rush; nations are discovering that space is the economic gemstone of the future and have aggressively jumped on the space bandwagon. As more nations gain commercial access to space, a byproduct is its eventual militarization. Many argue against such a precipitous shift, but with the intermingling of military and commercial enterprises that may be impossible. Others are resigned to the fact that the militarization of space is well under way and it may even be too late to reverse the process. (166: Arms Control In Space—original source America Plans for Space)

A case in point is the proliferation of high-resolution imagery on the commercial market. The U.S. and the former Soviet Union no longer enjoy the cold war monopoly on high-resolution imagery. Many nations and even private

enterprises now have timely access to this data. Either through national systems or indirectly through alliances or contractual agreements, modern nations now share an intelligence perspective once only held by the superpowers. This capability offers foreign governments and potential adversaries a distinct military advantage with real-time warning and intelligence. Lacking the national resources to develop these space capabilities, nations can simply purchase the information commercially. (Gonzales 1997, p23)

Table 16

High Resolution Imagery Capability

Nation	System (Current or under development)	Resolution
US		<1m
France	SPOT 5	2.5m
ESA	ENVISAT	SAR/EO
Russia	KR-1000	1m
Canada	RADARSAT	10m
China	Unnamed	2.5m
Brazil	China Brazil Earth Resources Satellite (CBERS)	5m
India	CARTOSAT 1	.5m
Japan	Advanced Land Observation Satellite (ALOS)	2.5m
Europe	Helios	1m
Israel	OFEC-3	<2m

Source:(Gonzales 1997, p23)

Aside from imaging, this commercial trend also includes access to navigation, weather, and communication systems. As the space market evolves, offensive and defensive capabilities will, just like imaging, be shaped by a supply-demand curve. For the right price, a high leverage space capability can be purchased by any group or nation. The commercial space market has translated technology into profit and is poised to dominate the development of space capabilities and shape the international architecture of our global space environment. The consequence of these commercial trends signals the potential erosion of our once unique military advantages and poses serious concern for future conflicts.

WHAT CURRENT AND DEVELOPMENTAL WEAPONS SHOULD BE EMPLOYED THROUGH, INTO, AND FROM SPACE?

Space combat weapons can be summarized into four distinct categories: earth-space-earth weapons, earth-space weapons, space-space weapons, and

space-earth weapons. The earth-space-earth weapons are reentry weapons launched from the surface of the earth with suborbital profiles and a capacity to strike any target on the globe. These reentry weapons include the traditional ICBM platforms with a capacity to carry conventional, nuclear, chemical, or biological warheads.

Within the categories of space-space, earth-space, and space-earth weapons, there are two tiers--kinetic energy and directed energy weapons. Translated, kinetic energy weapons are much like bombs and bullets. In the genre of space this includes employing physical objects at hypervelocities against targets. (20: New Sword - A Theory of Space Combat Power) Missiles, rods, pellets, and flechettes are all part of the kinetic energy weaponry arsenal. On the other hand, directed energy weapons are more for the Star Wars clientele. This league of weapons includes lasers, neutral particle beams, high power microwaves, electromagnetic pulse and plasma weapons.

ARE WE VULNERABLE TO SPACE ATTACKS?

With our growing dependence on space and information based systems, space has become a "center of gravity" in Clausewitzian vernacular. Logically, it follows that this center of gravity warrants protection. However, minimal defensive features exist in the current and next generation of civil and commercial space platforms. This creates a dangerous vulnerability for our operational forces. Although AFSPC has taken measures to protect our military space systems and deny unauthorized use of friendly systems, a tremendous vulnerability still remains. With the current trend toward coalition warfare and a clear reliance on a multitude of commercial space systems, the responsibility to protect and defend will grow exponentially within the next few decades. Realistically, protecting all of our commercial as well as military space systems is a Herculean task and will most likely fall to the Air Force. Building a defensive umbrella over these systems, especially ones we do not control, will be costly and require an extremely aggressive approach to the mission of counterspace.

IS OUR LEADERSHIP PREPARED TO FIGHT IN SPACE?

Recent wargames have clearly demonstrated a reluctance by leaders to consider space employment options early in a conflict. This reluctance stems from loosely defined space doctrine and the lack of a clear set of accepted

principles governing the conduct of space warfare. As an example, no agreement exists on the fallout or consequence of an attack on an adversary's ISR assets. These critical assets provide the enemy with invaluable situation awareness, and as any good warfighter will attest, should be targeted early in a conflict. Yet, wargames have revealed senior decision-makers are extremely cautious about the consequences of such offensive acts. Still anchored with the Cold War mindset, many senior decision makers perceive space attacks as a threshold of escalation and are apprehensive about using the proverbial silver bullet. (4: Space Doctrine and Strategy Issues- Integrated Wargaming Lessons) At the core of our leadership's reluctance is a poor understanding of space and its impact on warfighting doctrine of the last fifty years. Until we are prepared to merge space and its high leverage options early in a conflict, we jeopardize the success of our military engagements. Sadly, some argue the U.S. may lose its first space engagement due to political reluctance and hesitancy to use the offensive options of counterspace.

WHAT IS THE MOST SIGNIFICANT ISSUE FACING POLICY MAKERS?

Space control is likely the single greatest military space issue of the next two decades. Packaged as the "freedom of the high seas mission," the Air Force's space control mission guarantees unencumbered access to and free use of space as well as denying such benefits to our adversaries, if necessary. Interestingly, this protect-and-defend mindset places our space forces in a fairly offensive posture. Although today's space forces have an extremely limited counterspace capability, the DOD's requirements point to the likelihood of eventually developing an aggressive and comprehensive counterspace option.

Recently, an open letter signed by 43 retired senior military leaders to President Clinton warned that few challenges posed "a greater danger to our future security posture than that of adversaries seeking to make hostile use of space or to deny us the ability to dominate that theater of operations." (Powell 1999, p41) The emerging importance of this mission is clear. The protection of friendly space assets has become a military necessity and a preeminent national priority. As such, the significance of the space control mission is gaining ground on both policy and budget agendas. However, until our warfighting doctrine and its bedfellow technology can deliver in concert,

our future space control campaigns will be mired in indecision with lackluster results.

CONCLUSION

Today, over 30 nations control over 550 satellites orbiting the Earth with futurists predicting another 1,000-1,500 entering orbit in the next 5 years. (Powell 1999, p41) With those predictions, it is essential that we mold our national roadmap in space with unity of voice. This guide was written as a framework for those who will shape our future space policies and help map the curves and straight lines of our space roadmap. Intended as a simplistic starting point for those stepping into the space arena, the Executive Guide to Space is a beginning for anyone who intends to benefit from, rely upon or participate in space activities. This guide is not a detailed reference but rather an introduction to the issues and dynamics overtaking the space medium. The decisions we pen today depend on a robust and hearty contribution from all members inside and outside the space community. If we allow a one-sided debate with parochial interests, then our national policy will not strike the correct balance.

There are many forces shaping and molding our national direction: economic, military, and political. We cannot sit idly or wait for other nations to set our decisions in motion. It would be a travesty if another nation, or for that matter a business or organization, was able to easily force our hand with a space event. A groundbreaking step toward building cohesion within our national space effort was USSPACECOM's development of the first comprehensive single-source long-range plan in 1998. The priorities and vision set forth in the LRP is a watermark in our nation's space development.

Historical precedents, changing organizational relationships, international treaties, decades of doctrinal tugs of war, and exploding commercial markets have brought us to a national crossroads. The articulation of space policy resonates throughout our political and military hierarchy. Amidst the uncertainty, a consensus on our national space priorities must overcome parochialism. Secretary Whitten Peters echoed these thoughts and highlighted the uncertainty that our leadership faces when he spoke to the National Security Forum at the Air University in June 1999. Several Air Force initiatives are underway to help identify our space priorities--a Space Lift

Task Force, a Commercial Space Opportunity Study, and an Aerospace Integration Task Force. From the Air Force perspective, these studies will add clarity to the national debate, resolve much of the uncertainty, and move our national space imperative forward. As Secretary Peters concluded, it is time to build bridges between cultures and bring harmony to the users of space. (Peters 1999)

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